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Snag Boat With Snag on Deck.

THE CONTROL OF THE MISSISSIPPI FLOODS.—[See page 279.]

Commercial and Financial Aspects of Gas Manufacture—II*

A Retrospect of the Development of a Great Industry

By George B. Cortelyou

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1947, Page 267, April 26, 1913

The advent of electricity for lighting purposes did not, as some might suppose, check the progress of gas. On the contrary, as has been the history where improved methods of lighting have developed, both kinds of lighting profited by the increased efficiency; and since the introduction of the incandescent mantle, notwithstanding that the resultant yield of illumination per cubic foot consumed was practically quadrupled the reduction of gas output did not follow; but, on the contrary, vastly increased. The development of high-pressure incandescent lighting systems, such as are in vogue in the leading European cities, is another movement which bids fair to keep the gas industry to the fore.

PRODUCTION AND PRICES.

The trend of prices for gas has been steadily downward from the beginning. In New York city, for instance, the price in 1826 was $10 per 1,000 cubic feet; in 1846, $6; in 1866, $3.50; in 1880, $1.25; in 1897, $1.20; in 1898 $1.15; in 1899, $1.10; in 1900, $1.05; in 1901, $1; in 1906, 80 cents, the present rate. These reductions have been made possible by various economies in production, and particularly by the more extended utilization of by-products and by promoting the use of gas for domestic and industrial purposes.

Neither gas nor electric light has been a factor in the increased cost of living of which we hear so much. The Massachusetts Commission on Cost of Living reported that the average price for gas in that State in 1890 was $1.46 per 1,000 cubic feet, and in 1909, 91.4 cents, a decrease of 37.4 per cent in the period. The Commission also reported an increase in the prices of twelve staple commodities from 1897 tc 1910 of 51.7 per cent. During the same period wages also underwent a marked increase. If the experience of Massachusetts may be taken as fairly representative of the country at large, it shows that, in a period of steadily advancing prices, both for commodities and for labor, the public has had the advantage of a steadily diminishing price of gas for all purposes.

GAS SALES IN U. S. IN CUBIC FEET: QUANTITY AND PRICE PER CUBIC FEET.*

	M Cubic Feet	Total M Cu. Ft.	Average price per M CuFt	Amount	Total Amount
433 Companies reporting in 1898:					
Sold for Illuminating....	15,955,149		$1.188	$18,955,149	
Sold for Fuel.	2,476,051		1.029	2,549,181	
		18,431,200			$21,502,325
552 Companies reporting in 1908 (Oil and Water Gas):					
Sold for Illuminating....	76,804,546		.92	$70,294,158	
Sold for fuel..	26,542,951	103,347,497	.98	26,049,063	$96,343,221
506 Companies reporting in 1908 (Coal Gas):					
Sold for Illuminating....	32,485,571		.73	$23,599,930	
Sold for Fuel.	21,076,242	53,561,813	.65	13,627,971	37,227,901
Total Coal and Water Gas Sold....		156,909,310			$133,571,122

The output of gas has been continually on the increase, notwithstanding the competition from electricity. From the subjoined table it appears that in 1898 the companies reporting showed total sales of 18,431,200,000 cubic feet, for which $21,502,325 was received, an average price of about $1.17 per 1,000. Ten years later, 1908, the companies reporting showed total sales of 156,909,310,000 cubic feet, for which $133,571,122 was received, an average price of 85 cents per 1,000.

GAS SALES IN U. S. IN CUBIC FEET:—QUANTITY AND PRICE PER CUBIC FEET.

The growth in gas output, as compared with the growth in population, shows that the gas sales in large cities grow almost twice as fast as the population. For instance, in four great boroughs of New York city, the 1890 census and 1910 census compared, show an increase in population of 90.6 per cent in the twenty years, while the increase in gas sales, in the seventeen years from 1893 to 1910, was 164.6 per cent or, relatively per year, about 5 per cent for population and 9.67 per cent for gas.

COMPARATIVE STATISTICS—FOUR BOROUGHS OF NEW YORK CITY.

	Population:			
1890:	Manhattan.....	1,441,216		
	Bronx.....	88,908		
	Brooklyn.....	838,547		
	Queens.....	87,050		
			2,455,721	
1910:	Manhattan.....	2,231,542		
	Bronx.....	430,980		
	Brooklyn.....	1,634,351		
	Queens.....	284,041	4,680,914	
	Gain in 20 years (4 Boroughs)—		2,225,193	= 90.6 per cent.
	Gas Output:	M cu. ft.	M cu. ft.	
1893:	Manhattan & Bronx....	11,343,000		
	Brooklyn & Queens.....	3,439,000	14,792,000	
1910:	Manhattan & Bronx....	27,217,105		
	Brooklyn & Queens.....	11,900,000	39,117,105	
	Gain in 17 years.....		24,325,105	= 164.6 per cent.

Populatiod in four boroughs 4,680,914.
Sales in four boroughs 39,117,105,000 cubic feet, 8.350 cubic feet per capita per annum.

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GAS SECURITIES.

Gas has unquestionably for many years been a staple commodity, and its growing field of usefulness, in industrial work as well as for cooking, heating and other domestic purposes, has given gas securities a standing and stability hardly approached by any other class of investment. As has been shown, its ratio in increased output far exceeds the ratio of growth of population. For instance, the United States Census shows an increase in the decade, from 1909 to 1910, of about 21 per cent. In about one third this time—that is, from 1905 to 1908—the sales of gas increased from 117,866,000,000 cubic feet to 156,909,000,000 cubic feet, an increase of 39,043,000,000 cubic feet, or 33 per cent in three years. This would indicate an approximate increase of 100 per cent in the decade, or 5 times the ratio of increase given for the population, from which we may conclude that gas securities are destined to maintain their high place as desirable investments. It is claimed that no other class of bonds shows such a small percentage of defaults as gas securities. Quoting from a recent article in one of the financial journals we have the following:

"Gas bonds have a first class record for safety; they are usually secured by a mortgage on all the property rights and franchises of the company issuing it. The condition and value of the property are passed upon by competent gas and mechanical engineers before the bonds are issued.

"The bonds are issued only with the approval of a trust company, which is the trustee, after the trust companies have decided that the bonds may be issued in accordance with the terms of the mortgage and trust deed. A gas company operates under the franchise or license of a city, and usually only one company serves one community. It is a 'necessity' and the residents of the community use gas for cooking and lighting with practically the same certainty that they pay taxes or use the utilities furnished by the municipality itself. The business is operated on a broad foundation, relying on a small profit from many customers rather than a large profit from a few."

A study of the gross and net earnings of lighting companies shows that the effect of periods of commercial depression such as were experienced in 1907 and 1908 is slight as compared with the effect upon the earnings of general industrials. The variation between the two is very marked for such periods, the earnings of lighting companies showing a material gain, while those of general industrials show a decided falling off.

A tabulation covering three years for 61 prominent cities in the United States, all of which have well established sources of electrical supply, shows an increase in gas consumption from 1899 to 1902 of 31 per cent. In its widening field for industrial purposes, two powerful factors work for its development; the first of which is the fact that it requires no space for storage on the user's premises, secondly, it is smokeless and eliminates the troublesome factors encountered in almost all other fuels—the handling of the fuel itself, incidental refuse, ashes, and the like.

In view, therefore, of the position of the gas industry, its continued growth and the variety of purposes to which its services may be put, it is fair to predict that, properly operated and with constant provision for invention and improvement, the business will steadily increase.

SOME AGENCIES FOR PROMOTING THE SALE OF GAS.

No discussion of the subject that has been assigned me in this series would be complete without a reference to the work of the National Commercial Gas Association, which formed a most important connecting link between the producer of gas and the user. It is conceded that a material factor in reducing the cost of gas production is increasing the output.

It is, of course, of vital importance that the product of the plant shall be of the required quality and that its manufacture and distribution shall be at the minimum cost consistent with quality requirements. This is certainly worthy of the best thought and effort of the technical man, and this work is likely to make such a demand upon his time as to preclude the possibility of his devoting any considerable attention to the commercial problems connected with the industry.

Salesmanship has become a science, and interchange of ideas and the discussion of ways and means for selling the engineers' product make the importance of commercial gas associations loom very large in the gas world of to-day, as it is mainly through the development and extension of this arm of the industry that the problem of enlarging the field of usefulness of gas must be solved.

It is with us as with other industries. If we are to have the highest efficiency it must be through specialization. I believe the money of the gas company is well spent when it develops specialists in the selling line, and this brings to mind the fact that a close observation should be kept over the office man to see that those who deal with the public are sufficiently well informed and have the capacity to supplement thoroughly the salesman's work and to deal with the public in a satisfactory manner.

The commercial gas men have inaugurated aggressive selling campaigns, have instituted schools of salesmanship and have brought together the manufacturer, seller and user of gas appliances at their conventions, an important feature of which is the exhibition work demonstration of the latest and best gas-using devices. I am informed that a Commercial Gas Association has been formed in London similar to that in this country.

I am also a firm believer in the value to lighting companies of newspaper publicity; that is, going direct to the public through the advertising columns of the daily papers, telling in a plain, straightforward way of our product and our service, explaining the things which to the trained gas man may seem rather elementary, but which to the average man are more or less of a mystery. I know of nothing else that is more promotive of good relations between the gas company and the public than a frank declaration of the principles and policies of the company, as a public service corporation, made without reservation and thoroughly lived up to. Following the establishment in this way of a broad foundation of confidence, the company may advertise special appliances or particular features of its service, of the more strictly "business-getting" sort, with the certainty that the returns will amply justify the expenditure.

But, even to-day, a man ushered into the lighting world faces a field filled with skeptics. In the minds of many there is an inherent feeling of bias against the lighting man, primarily perhaps by reason of the fact that the average individual has no conception of the commodity we sell, its manufacture, the immensity of the time, money, energy and skill required to build up a gas lighting business; and this feeling of distrust is augmented by the fact that the commodity is of so intangible a nature that the buyer of it has no visual knowledge of its coming into his possession as a commodity; to the average man, *selling gas* is a thing apart from *selling light*. The commercial proposition of selling our commodity is further handicapped in the operation of selling as compared with other products which may be shown by the seller. It lacks attractiveness in display, in fact, has none in itself, cannot be basketed and bundled up and carried away by the user who has chosen his purchase for its attractive appearance, has seen it measured by the yard or bushel, or weighed by the pound and taken in the hand and carried to the house. The gas man has also inherited a deep seated antipathy of the user of his product by reason of the uncommercial methods of many of his predecessors in the business. Dealing as we do with all classes, all nationalities, all grades of people, and with those who to a great extent commenced doing business with us with this inherited prejudice, we are at once put upon the defensive. In dealing with the commercial proposi-

*Address delivered on the occasion of the celebration of the Centenary of the Use of Gas as an Illuminant, Franklin Institute, Philadelphia, Pa., April 19th, 1912.

* Compiled from Report of Department of the Interior, U. S. Geological Survey (1902 and 1908) H. W. Parker.

tion we must make a large portion of our work the uprooting of this prejudice, and this does not demand so much of our engineers and gas makers as it does of our commercial department men, those who meet the public and who are large factors in our service. And this word *service* should show up large before the employee of any public utility corporation. The shortcomings of a supply as to pressure, candle power efficiency and other essentials, are apt to be the matter of a moment, and when remedied in a gracious manner leave no rankling; but the shortcomings which are evident in poor service, brought about by inattention, neglect, or slipshod methods, are not so easily effaced from the consumer's mind. So, I say, this word *service* should be writ large in the mind of every worker for a public utility corporation. Some of our forbears did not appreciate this end of the business as vital to the commercial success of our industry, but we are getting away from old-fashioned methods and we feel that we have made great strides in this direction in the last few years.

When one reflects upon the truism that "One man on the block makes public opinion," and that there is a large probability of there being at least one unreasonable individual living within the area of a city block, it is not strange, in view of the fact that the satisfied gas consumer does not go to the trouble of announcing his satisfaction from the housetop, that is, not to the extent of disturbing his neighbors or keeping them awake with his joyous ebullitions, that the gas man is on the defensive a very considerable part of the business day. And this is in part because the gas man has allowed an air of mystery to surround his business. He has not given enough time and attention to educational work among his patrons—has not tried to explain the workings of that mysterious black, tin box in the cellar, of which the average consumer stands in dread and to whose ear the little clicking noise of its mechanism is so ominous. Happily we are to-day on the road to enlightening our customers by giving to our employees a knowledge of these common things of the business, of which, up to a comparatively recent time, they were wofully ignorant.

IMPORTANCE OF LIGHT TO THE GROWTH OF CITIES.

As a factor in the growth of cities it is generally conceded that the lighting company is a positive force for the general good. The importance of its work in providing the public with more and better light is appreciated by all who are connected with the development of municipalities and particularly of suburban districts. The value of light to a municipality, from the purely commercial point of view, is becoming more and more recognized, as is evidenced by the agitation among merchants the country over for additional street and store illumination. These tradesmen know well the value of illumination, both in the matter of window display and in the general publicity it attracts to the lighted district and to the city as a whole. Light is the world's best policeman, for crime instinctively seeks the shadows and the dark corners. I believe that many of our American cities could find no better way of cooperating with the efficient police bodies they have than by thoroughly illuminating the communities to the very limit of municipal control.

In "King's Treatise" we are given this interesting information concerning the early days of gas lighting:

"The police officers from Worship street and other places gave evidence of the great utility of gas lighting in preventing robberies, and they also mentioned an instance where perpetration of this crime had been apprehended by its aid. Also that three-fifths of the street oil lamps were extinguished before midnight, and that the thieves would borrow ladders from lamp lighters for the purpose of committing robberies." This was brought out in connection with an application made in London, in 1816, by the Chartered Gas Light and Coke Company for an increase in capital.

THE MODERN GAS COMPANY IN ITS RELATION TO THE PUBLIC AND THE MUNICIPALITY.

As a necessity; as a convenience; as a promoter of trade; and as a source of good or ill-will as between the company and the community—the last named largely in proportion to the degree with which the company's affairs are conducted with business sagacity and common sense it is a public service corporation. Its rights and the rights of the consumer must be safeguarded if both are to realize beneficial results. It is not a one-sided proposition; one falls unless the other is supported. They are inter-related; they should be friends, not enemies. It is a mischievous interpretation of their relations that groups all the wrongs on one side and all the rights on the other.

To repeat all the arguments for the company and for the consumer is not my purpose, nor is it necessary at such a time. It is sufficient to say that the relation of the company to the municipality should be characterized by integrity and efficiency of management and fair and impartial treatment of all who do business with it. In turn, when the public is fairly and efficiently served, that is, with the best service at the lowest rates compatible with a just estimate of their respective relations, the municipality should support and encourage the company. As I have said upon another occasion, the public is less concerned with the precise rate it pays than it is with having thoroughly efficient service. If the company is honestly conducted, and its affairs are given that degree of publicity which is proper and is the public's due, it does not begrudge to the company adequate returns, nor will it yield to the screamings of the demagogue or the self-seeker when he misrepresents the facts or encourages unjust attacks. On their side the companies must keep out of politics, and the mystery of management must become less of an obsession with those who have important undertakings of this character intrusted to their hands.

Of course, all this presupposes a full recognition of the rights of employees. No company will have permanent success, or deserve to have it, unless those whose labor has so vitally to do with the enterprise are regarded as an integral part of it. Adequate wages, reasonable hours, generous treatment all along the line, with a system of management that encourages to the highest possible degree the spirit of the individual worker, are all their due and are recognized by the enlightened corporation.

If one thing more than another is a menace to industrial progress, I believe it is the untenable position assumed by some extremists who would limit the return allowed to such corporations as those which are of the public utility class to a rate so low that it either barely equals the legal rate of interest, or taking into account the varying factors that must be considered in the case of each company, a rate that is practically but a fraction above confiscation. To induce original investment and development, to insure progress after establishment, to safeguard both the company and the community, a return, not merely theoretically but actually fair and liberal, must be permitted if the normal laws of trade are still in effect, and we believe that they are.

It should be remembered that when franchises were granted to public utility companies they were granted with the idea that a service absolutely essential to the growth of the community was to be provided, and it must also be remembered that in many cases those who obtained these privileges or franchises faced a serious risk in making their investment, that there was no assurance that an adequate return would be forthcoming for the money and energy expended in the building up of the service.

A factor which the unthinking man should have brought to his notice, when the supposed enormous profits accruing to lighting companies are discussed, is the ratio between investment and gross income. Investigations shows that the annual gas sale of many of the companies do not exceed $15 for each $100 of investment. It must not be inferred from this that these companies make $15 per year on every $100 investment, but that their actual sales each year amount to about 1/7 of the money invested. This would indicate an investment of $7 for each 1,000 feet of annual sales at $1 per 1,000 approximately. In other lines of business it is expected to turn over the capital once, twice or three times a year, but here is a business in which millions are invested in which the capital is turned over only once in about seven years.

It has come to be well nigh axiomatic in the gas industry that each company must be considered on its merits, that hardship and injustice result when one company is expected to meet all the requirements of the business under the same restrictions as every other. Engineering difficulties, extent of territory, character of population, maximum demand, and a number of other considerations must in each instance be given fair and proportionate bearing upon the entire problem. But we cannot expect all of the desirable factors to which I have alluded to be fully developed at once; substantial and permanent progress in any industry, in any line of human endeavor, is usually of slow growth, but we can work toward them with the certainty that the material returns will be gratifying, and that we shall be contributing, if only in a slight degree, to the establishment of efficiency and equity and justice in our commercial transaction.

Automatic Railway Signaling*

A NUMBER of railway engineers and others recently inspected the working of a series of devices for automatic railway signalling invented by Mr. A. R. Angus of Sydney, Australia. Mr. Angus is conducting his operations upon an unusually complete scale. He has obtained possession for an extended period of the West Somerset Mineral Railway, a single-track line which runs from the coast at Watchet up to the Brendon Hills, but which has been disused for some years; and he has relaid the permanent way for a distance of about two miles between Watchet and Washford in such a fashion that he can carry out tests under practical conditions at speeds of 60 or 70 miles an hour with the aid of two large tender locomotives purchased from the Great Western Railway Company.

NATURE OF THE PLANT.

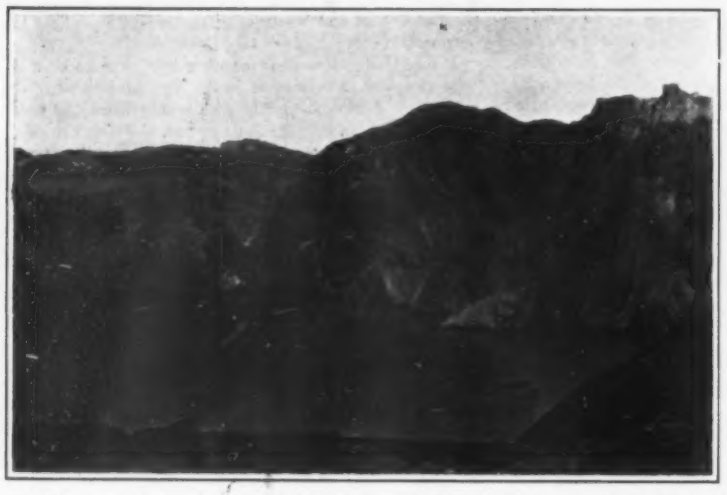
Recognizing that railway collisions are caused in many cases, not by defects in the signaling plant, but by engine drivers disregarding or mistaking signals, he has applied himself to the fundamental problem of eliminating the personal element. Owing to the fact that some of his patents are not yet completed he is unable to reveal the precise construction of the mechanism he employs, but he is in a position to demonstrate some of the results he can obtain. The two miles of track which he has reconstructed are divided into three sections, and between every two sections there is a signal box. These signal boxes, which would perhaps be better termed control boxes, enable the stationmaster or other authority to direct the course of trains at junctions, and to determine what train shall have priority of admission into a given section of a single line. In each section there are six ramps, three toward one end and three toward the other, placed between the running rails; they are 30 or 40 feet long, and are similar in construction to those which are employed for signalling purposes on certain portions of the Great Western Railway. Standing up a few inches above the level of the rails, they are struck by a shoe which depends from the locomotive and which is so shaped as to reduce the shock of the impact to a *minimum;* and they are connected electrically to an overhead telegraph wire which runs alongside the line. As a matter of fact, two wires are used on the Watchet installation; but one is stated to be sufficient. The return is by the earth. The source of the power which works the apparatus is carried on the engine; it may be a generator of any kind, but at Watchet it consists of a battery, and the current employed is measured in milliamperes, with a very low voltage. The ramps, the telegraph wire, and the apparatus on the engine and in the control boxes constitute the whole of the equipment, and there are no outdoor or fixed signals. It is claimed, therefore, that apart from questions of safety, the cost of equipping and maintaining such a system would be very small.

WORKING OF THE APPARATUS.

The indications given are in every case positive; that is to say, the engine-driver is informed if the section he is about to enter is free, and he is equally informed if it contains another train. Supposing the section in front of him to be clear, then when the engine comes over the first of the three ramps at the end of the preceding section a deep-toned whistle is sounded, and it is again sounded at each of the other two ramps in the section, and also at each of the three ramps at the beginning of the succeeding section. The whistle is chosen because the action of the apparatus has to be demonstrated to a large number of people, all of whom cannot be on the engine, but a miniature semaphore, or a colored light, or a bell, or a buzzer can be put on the engine in substitution, as preferred. But supposing that the following section contains a train and therefore cannot be entered without danger, then the indications are equally positive, and, moreover, are translated into action if the driver does not heed them. At the first of the three ramps toward the end of the preceding section a shrill whistle is sounded or some other equivalent sign is given. The driver is free to ignore it if he likes; indeed, he is able to switch out the whistle or other device so that no visual or audible intimation is given him. But if he does so, then at the second ramp he finds that the control of the train is taken out of his hands, because the throttle is closed automatically and the continuous brake is applied. From this predicament the way of escape is not easy, for he has to go through various formalities before he can obtain the key that will enable him to leave the section, and he stands convicted of the most heinous sin he can commit—that of ignoring signals. If two trains are running in opposite directions on two adjacent sections of a single track line, warning is given to both of them, and if no attention is paid to it the steam is cut off and the brakes applied on both. The position of the ramps is, of course, so chosen with reference to the gradient, the average speed, the braking power, and other circumstances, that the trains are brought to a standstill before they enter forbidden ground.

As regards defects in the apparatus, should there be a short circuit the two whistles, shrill and deep, sound simultaneously, and disregard of the warning leads to automatic stoppage of the train. Similarly, if the telegraph wire be severed, or the engine start off without a battery or with an exhausted battery, the result is the same; the apparatus, which the inventor styles an "electrical brain," finding that it does not get a response, concludes that something is wrong, and as a precaution shuts off steam and allows the brakes to go on.

* Reproduced from the London *Times*.



The North Polar Regions Have Sternly Guarded Their Unknown Areas With Shifting Ice Over Deep Sea. Cotidal Experts Now Maintain the Existence of a Land Mass, Possibly of 500,000 Square Miles, in What is Represented as Open Polar Basin Immediately North of British America and West of the Arctic Archipelago.

Arctic Exploration And the New Stefánsson Expedition*

By Robert E. Peary

It becomes more and more an age of doing great things, of directing private, institutional and national wealth into channels for great results, and I am glad because of my keen interest in polar exploration, that some of the great things to be done are still to be found in the fastnesses of the Far North notwithstanding four centuries of interest and pioneer work.

Exploration has shifted decade by decade from one continent to another and from the Arctic to the Antarctic. The search for the North Pole was carried on many years before that for the South Pole began. Now both poles have been attained, together with a large body of scientific fact, geographical and otherwise, brought back by the various exploring parties. The globe about the two poles has held its mystery guarded most sternly of all the regions of the earth, especially about the North Pole where there is no land and the explorer can proceed in winter and earliest spring only, making hazardous journeys on shifting ice over unfathomed ocean depths. With all that has been accomplished, many hundred thousands of square miles still remain of the three million square miles of uncharted territory that existed prior to the expedition that resulted in the discovery of the pole. To complete this exploration, to replace with knowledge the tradition and theory accrued during past years is the step immediately before us and cannot fail to be of great value to science.

Of unexplored regions in the north, there are remaining but two of first importance: the inland ice cap of Greenland and the area represented by the large blank space on the map bounded by Bering Strait and the pole, the western border of the Arctic Archipelago and the known open sea north of Siberia. The theories of cotidal experts have it that within this region lies an undiscovered Arctic continent, or a series of large islands separated by narrow channels, the whole not greatly distant from Banks Island, Prince Patrick Island and Grant Land (the western limit of the Arctic Archipelago), while tradition among the Eskimo and indefinite reports of whalers strengthen the theories in fixing the southern edge of the unknown land not far north of Point Barrow and the northern shores of America. I must believe in the existence of such land, one corner of which I saw from Cape Thomas Hubbard in July, 1906, in the mountain peaks of Crocker Land.

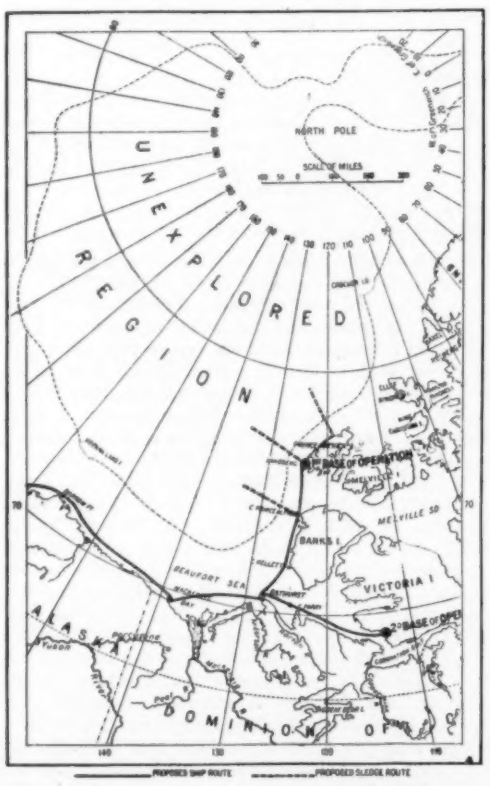
If land of large extent be located west of Banks Island and Grant Land, the discovery from the standpoint of future exploration will be of unusual importance, since the new land will be a base for penetration of the remainder of the unknown area to the west. In fact, since the theory of the existence of extensive land, one corner of which is Crocker Land and another not far from Banks Islands, seems so likely to me and is so well accepted by many expert geographers and mathematicians, I would divide the remaining greatest problem in the North into two separate problems—namely, the exploration of this land area and the exploration of the adjoining area beyond, between the pole and Bering Strait.

The eyes of the scientific world are on the projected expeditions which have for the geographical part of their work a search for this uncharted land. The Crocker Land expedition, under the auspices of the American Geographical Society and the American Museum of Natural History, has been announced for more than a year, having had its activity deferred by the deplored death of George Borup, its prospective leader. An announcement is now definitely made that the Stefánsson expedition reported some months ago as likely to proceed on polar investigations under the auspices of the National Geographic Society and the American Museum of Natural History is to proceed with most liberal support as an expedition of the Canadian Government.

The Scott tragedy, which has made men's names imperishable and brought the heroic in human nature strongly to all people, has set an emphasis upon expeditions about to enter polar work. Mr. Stefánsson will carry not only a well-equipped expedition into the vastness and bleakness of the north, but also with it the thought and warm heart of the world left in the comforts and comradeship of civilization.

In personality and from training and experience, he is especially fitted for this work, his courage and control of untoward circumstances have been proved in the six years he has already put in on Arctic investigations, and he has shown executive ability and judgment in his plans for organization of the new expedition. I am glad that in addition he has some of the qualities of a dreamer. For the greater work of life requires the man to whom a vision can come with such allurement that he must follow its leading through all obstacles and many years, goaded always to express the irresistible power within him in the accomplishment of that vision. And when I recall that to these characteristics he adds the hardy qualities that come from his ancestry of the north and to these still again the authority of science from his training as an ethnologist, I can but congratulate the scientific world and the Canadian Government that Vilhjálmur Stefánsson has stepped forth to do a man's work in Arctic exploration.

As I said regarding the Crocker Land expedition, I would that my years were fewer that I also might penetrate again into the enchanted solitudes. I can hear the yelping of the dogs, the shouting of the drivers and forward rushing of the sledges, as after days of weary travel across the ragged sea ice, every man and dog spurts for the shore of that untrodden land lying a few yards ahead in the brilliant Arctic sunlight.



Proposed Route of the Stefánsson Expedition.—A Map Prepared Under Vilhjálmur Stefánsson.

Proposed sledge and ship routes and bases of operation of the Stefánsson expedition originally planned under the auspices of the National Geographic Society and American Museum of Natural History and finally transferred to the support of the Canadian Government. The expedition will sail in May from the Canadian naval station at Esquimault, British Columbia, with the recently purchased "Karluk," 247 tons, for exploration work covering a period of from three to four years.

"Your base is one of the nearest, and perhaps the most accessible point for an attack upon the largest remaining unexplored areas within the Arctic Circle."—Quoted from a telegram from Peary to Stefánsson, November 16th, 1912.

Plans of the Stefánsson Expedition*

By Clark Wissler

A new expedition to carry on the work begun in part by the Stefánsson-Anderson expedition was projected some months ago in the interests of the museum. Immediately on the return of Mr. Stefánsson from his four and a half years in the Arctic, plans were set in preparation in the museum for this second expedition. The National Geographic Society of Washington initiated the subscription with a large sum for the geographic part of the work. This organization also agreed to co-operate with the museum in whose behalf Mrs. Morris K. Jesup contributed half the funds required for the expedition. While arrangements were being made for the expedition to set out in May of this year the Canadian Government, which through its geological survey was a party to the original Stefánsson-Anderson expedition, made a proposition to take over the entire expedition and to provide a large fund for its support as well as to make it a governmental mat-

* Reproduced from the *American Museum Journal.*

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ter. While this is a great loss to the museum, it is but fitting that such an important expedition into Canadian territory should be controlled by Canada.

I quote the following letters by the Prime Minister of Canada and the president of the American Museum:

New York City, February 12th, 1913.

Dear Mr. Stefánsson:

The offer of the Canadian Government, through the telegram of the Hon. William J. Roche, Minister of the Interior, on Monday, February 10th, to cover the entire expenses of an expedition to the Arctic, places the plans you have made with us and with the National Geographic Society in a new light.

It would appear that this offers an opportunity of conducting your explorations under the direction of a strong Government which, through patriotic as well as scientific motives, will take every possible step to insure success.

We feel bound, under these circumstances, to relinquish the claim which our prolonged preliminary negotiations and understanding may have given us upon your expedition. We desire you to conduct your negotiations, therefore, with the Canadian government, with entire freedom.

It is, however, with the greatest reluctance that, through our desire to do what seems best for the general interests of science, we sever a connection established in 1908 with yourself and Dr. Anderson, which has been animated throughout by warm personal regard and which has been attended by the achievement of such notable scientific results. We desire especially to make record of our appreciation of the heroic and self-sacrificing efforts which you and Dr. Anderson made in carrying out the project of the first Stefánsson-Anderson expedition.

In case you enter upon this proposed service of the Canadian government, I am sure that the entire scientific staff of the American Museum will unite with me in the expression of our heartiest goodwill and of our desire that you may successfully accomplish all the objects that you have in mind in the way of further exploration.

In view of our past friendly co-operation with the Canadian survey, we trust that continued co-operation with this museum, especially in certain lines of anthropology and zoology, may be arranged for in connection with your expedition.

Believe me, with the highest regard,

Faithfully yours,

Signed. HENRY FAIRFIELD OSBORN.

President of the American Museum of Natural History.

PRIME MINISTER'S OFFICE, CANADA

Ottawa, Ontario, February 21st, 1913.

Dear Sir:

Mr. Stefánsson has shown me your letter of the 12th instant stating that you are willing to forego your claims to a share in his exploration of the northern waters of Canada, and to cancel the arrangements which you had so generously made to contribute toward the expenses of this undertaking, and I wish to thank you for your courtesy in withdrawing in favor of this government.

We are most appreciative of the valuable results obtained by Mr. Stefánsson's explorations in the northern part of the American continent, which have given valuable information as to this comparatively unknown portion of the Dominion of Canada, and have to thank you for the part you took in assisting Mr. Stefánsson in that work. The government of Canada feels, however, with regard to the present exploration, that it would be more suitable if the expenses are borne by the government more immediatly interested, and if the expedition sails under the flag of the country which is to be explored. The government is, however, desirous that the line of investigation begun by Mr. Stefánsson and the members of your association should be continued and would be glad of the scientific co-operation of your members so as to obtain the best results from this expedition.

Signed. Yours very truly, R. L. BORDEN.

It is Mr. Stefánsson's present intention to carry out in detail the plan as formerly developed in the interests of this museum and the National Geographic Society. Its chief aim will be geographical and anthropological exploration. As planned, the expedition will have two main bases, the northern one on Prince Patrick Island and the southern on the mainland of North America near Coronation Gulf. Mr. Stefánsson will give personal attention to geographical exploration and the study of the Eskimo, Dr. Anderson will conduct the biological investigations. It is expected that a staff of at least six scientists will accompany Mr. Stefánsson, Dr. Anderson being one of that number.

In general, the plan is to spend three or four years in an intensive study of the archæology and ethnology of the Eskimo, together with the zoology and geology of the whole region from Alaska to Coronation Gulf.

Also, to map the unexplored coast of Victoria and Prince Patrick islands and by off-shore journeys to the north and east determine by means of soundings the extent of the continental shelf and discover new lands, if such there be. It is intended that the expedition shall be a scientific one and devote its energies to the investigation of this unknown region.

The anthropological work is to be made a special feature, the main problem here being to determine the present and former limits of human occupation. During summer the surface will be searched for traces of former villages which when found will be carefully studied by excavation and otherwise to determine their relative ages and the cultural character of their occupants. Such archæological work is now needed to estimate the period of occupation and the direction of Eskimo migration.

In the east, special attention will be given to the distribution of the peculiar hybrid Eskimo discovered on the last expedition. It is intended that a full census of the people be made, noting the somatic character of each to serve as a basis for the study of this peculiar biological problem.

The Hardness of Metals

Theoretical Basis of Metal Working

By Thos. A. Eastick

Fig. 1.—High Carbon Steel. Dark Area is Pearlite. Long White Crystallites are Cementite. Magnified 300 Diameters.

THE valuable physical properties of metals upon which their use in engineering practice mainly depends are tensile strength, or resistance to a pulling or pushing force; elastic limit, or the ability of a metal to be forced out of shape and then recover its position, i. e., flexibility or "springiness;" and finally, toughness, a property somewhat hard to define, but which may be gaged, say, by the amount of pulling, bending or twisting a metal will undergo before rupture occurs.

Hardness is a combination of all these properties, and to harden a metal implies that the tensile strength and elastic limit are increased.

A metal may exist in various degrees of hardness, and when in its hardest condition is very different from its soft state. A dead soft copper rod, for example, may show only a tensile strength of 30,000 pounds per square inch, but when it has been cold

Fig. 2.—Pure copper. As Cast. Magnified 85 Diameters.

Fig. 3.—Pure Copper. Same as Fig. 2 After Hard-Drawing. Magnified 85 Diameters.

Fig. 4.—Same as Fig. 3. After Annealing. Magnified 85 Diameters.

Fig. 5.—Steel Containing 0.80 per cent Carbon. Pearlite Entirely. Magnified 400 Diameters.

Fig. 6.—Low Carbon Steel. Small White Specks are Pearlite. Dark is Ferrite. Magnified 200 Diameters.

drawn through steel dies till it is only half its former diameter it will show a tensile strength of 50,000 pounds per square inch, while the elastic limit is greatly increased and its electrical conductivity is reduced.

Metals and alloys become hard when cold-worked, i. e., hammered, rolled or drawn, and within certain limits, the severer the mechanical operation, the harder the metal will become. If, however, the working is too severe, the metal will of course rupture.

Before describing hardness and methods of hardening further, let us examine what is known as the stress-strain diagram obtained by testing a metal in a testing machine.

A testing machine, as is well known, is a machine for subjecting a given specimen to a strain, which may be read off in pounds on a beam. It consists mainly of a pair of jaws in which the sample is fixed, a beam on which is a sliding weight, and a screw gear operated by power by which a constant pull is obtained. One jaw is connected with the beam and the other with the screw gear.

When the machine is first started the beam is jerked up, showing that the specimen is under considerable tension, the weight on the beam is then quickly moved along the beam until a balance is obtained, the weight required to obtain this balance is usually taken as the "yield point" (on small machines this is sometimes taken as the breaking strain), because a few seconds after this balance is obtained the specimen suddenly elongates, the beam drops showing that the specimen is no longer under tension, the specimen rapidly "necks out" and then breaks.

The changes undergone by the specimen under test may be shown graphically by plotting the tension in pounds per square inch against the elongation expressed as percentage, as in the first diagram.

By this diagram it will be seen that the metal elongates very little under increasing loads until it reaches the elastic limit when it "gives" and then rapidly elongates until the yield point is reached, at this point the metal, slowly at first, and then rapidly "necks out" to the breaking load.

To return to the consideration of hardness; in order to harden a metal we must overcome its elastic limit, otherwise cold working will have no effect.

The effect on the crystalline structure on a metal produced by hardening it, is very striking. Fig. 2 is a photograph showing the appearance of a piece of copper as it is cast, under the microscope, Fig. 3, shows the same copper after having been drawn into wire. It will be noticed that the large grain structure has been entirely destroyed and the metal after drawing appears as an amorphous mass.

In the rolling and drawing of metals and alloys this hardening up is a very important item. In drawing copper wire, for instance, after the first few draws the metal becomes too hard to draw further, and it is then annealed.

The effect of annealing on metals is to cause recrystallization. The molecules of the highly strained metal, when heated, rearrange themselves in a crystalline condition, and the metal loses its hardness and becomes more ductile and tougher.

The sample of hard-drawn copper wire in Fig. 3 was annealed by heating it in a furnace at a temperature of 800 deg. Cent. for 15 minutes. A section was cut off and examined under the microscope. Fig. 4 shows its appearance. It will be noticed that the particles of the metal have arranged themselves in well formed and defined crystals.

Annealing, or the formation of crystals in a metal is effected by heating the metal to a certain temperature, which depends on the melting point. Thus copper which melts at 1,087 deg. Cent. may be softened rapidly by heating to 800 deg. Cent. Hard zinc, on the other hand, which melts at about 430 deg. Cent. may be softened by immersing in boiling water for some time. The higher the temperature the more rapidly the recrystallization proceeds and the consequent softening.

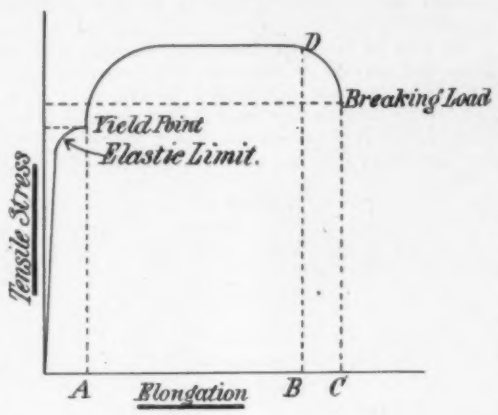
The dynamical theory of the hardening of metals by cold-working is somewhat complicated, but an idea may be obtained by a consideration of the following:

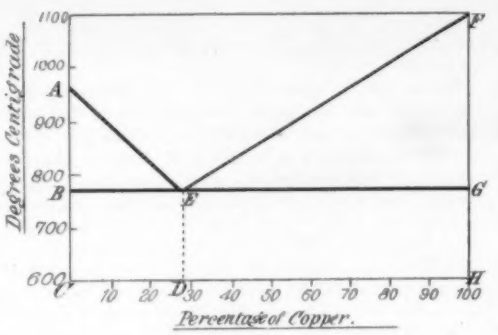
First. The smaller the crystal grains of a metal are, the harder and stronger will that metal be.

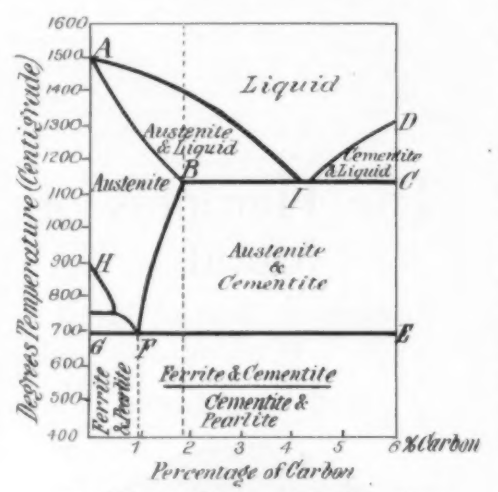
Second. Under the influence of working, the metal assumes a semi-fluid condition and then instantaneously becomes solid again upon the release of the pressure of the rolls or hammer, as the case may be.

Third. The sudden return of the metal from a semi-fluid to a solid form, naturally induces an exceedingly fine crystal structure. This structure is so fine as to be invisible under the microscope.

The explanation of the second item above is that under the sudden application of great pressure of the rolls the metal momentarily becomes liquid and then instantly solidifies. The structure shown in Fig. 3, therefore, consists of exceedingly minute crystals too







Equilibrium Diagram. Carbon-Iron Alloys

small to be seen under the microscope. Upon heating, however, these crystals coalesce to form larger ones.

This theory is the one generally held by metallurgists and was first enunciated by Dr. Beilby of London.

In dealing with iron and steel we find that there is another type of hardness, very different from what we have considered so far.

As is very well known, if we take a piece of steel and heat it red hot and then plunge it into water, it becomes intensely hard, so hard, in fact, that unless it be "tempered" it will break and fly into pieces like glass when bent. The phenomena of hardening by quenching steel will now be dealt with.

Steel consists of iron containing from 0.15 per cent to 2 per cent carbon. With less carbon than 0.15 per cent the metal is known as wrought iron, "ingot iron" and various other trade names. With more than 2 per cent carbon the metal approaches the composition of cast iron or pig iron.

Carbon forms with iron a chemical compound of the formula Fe_3C, and it is in this condition that it exists in steel. Upon examining different samples of steel containing various percentages of carbon we find that three different constituents may be distinguished. These constituents, on account of their resemblance to mineral or rock sections, have been given mineralogical names; they are ferrite, pearlite and cementite.

Ferrite is chemically pure iron, absolutely free from carbon. It is soft and possesses little strength. Wrought iron, "ingot iron," and very mild steel consist almost entirely of ferrite.

Cementite is the compound of carbon and iron mentioned above, having the formula Fe_3C. It is an intensely hard substance and may be observed in high carbon steel, tool steel, etc.

Pearlite, as its name implies, is a "pearly" looking constituent which consists of a very intimate mixture of ferrite and cementite. This mixture is known as an "eutectoid," it has a composition similar to a chemical compound, but yet is merely a very intimate mechanical mixture. It is called an eutectoid on account of its similarity to an eutectic; details concerning eutectics, etc., may be found in a previous article in the SCIENTIFIC AMERICAN SUPPLEMENT, May 4th, 1912, p. 276.

Steel containing about 0.80 per cent carbon consists of pure pearlite, and has the appearance under the microscope of Fig. 5. A steel containing less carbon than this consists of a conglomerate of ferrite and pearlite; the less carbon, the less pearlite is there. Fig. 6 shows the appearance of a low carbon steel or "mild" steel, as it is known. When the carbon exceeds 0.80 per cent cementite begins to appear in the form of a hard, white material which exists between the grains of pearlite. Fig. 1 shows the appearance of a piece of high carbon steel containing 1.20 per cent carbon.

In the previous article, referred to above, the use and construction of what are known as equilibrium diagrams, was described. These equilibrium diagrams are of great value in metallography and are obtained by co-ordinating the melting points and percentage composition of a series of alloys of two metals. Thus in the alloys of copper and silver, from 0 per cent copper to 100 per cent copper, the melting points of a number of experimental alloys from the ordinates while the composition, in per cent, of the alloys form the abscisse. The second diagram shows this curve. From this curve we can tell the approximate constitution of any alloy at any temperature. Thus, all alloys above the line *A E F* are liquid. Those in the space *A B E* consist of a liquid eutectic of copper and silver, in which are floating solid crystals of silver. Alloys in the space *E D C B* consist of a solid groundwork of silver surrounded by a network of the eutectic of copper and silver. Those in the space *E F G* would consist of the liquid eutectic in which are floating crystals of solid copper, while those in the space *E D H G* consist of solid copper crystals surrounded by a network of solid eutectic. For example, a United States ten-cent piece, which is an alloy of copper and silver containing 90 per cent silver and 10 per cent copper, at an ordinary temperature, would correspond to a point in the space *B E C D*, and would therefore consists of crystals of silver surrounded by a eutectic of copper and silver.

To return to steel, an equilibrium diagram has gradually been constructed by the work and observation of many masters, after infinite trouble and pains. This diagram is without doubt the hardest to construct in metallography on account of the very high melting points of the material, the difficulty in obtaining samples of the desired composition and the extreme complexity of these alloys of carbon and iron; yet this diagram is perhaps more valuable, industrially, than any other. However, it has been done, and our last diagram is the most recently published.

It will be only necessary to consider the left side of (the long dotted line on) the diagram, because steel rarely contains more than 2 per cent carbon.

All the alloys above the line *A D* are liquid; this line is therefore the line of solidification. In the space *A B I* the metal will consist of crystals of austenite (a constituent of steel which will be described below), surrounded by a still liquid mass of pearlite. In the space *A B F H* the whole mass will solidify as a homogeneous *solid solution:* This solid solution is called austenite after Sir Roberts-Austen, the great metallurgist. After cooling below the line *H F B* this solid solution splits up into its constituents, ferrite and pearlite, provided that the percentage of carbon does not exceed 0.80 per cent or 0.90 per cent. Should the carbon exceed this, there exists, below the line *B C* a conglomerate of austenite and cementite; on cooling below the line *F E* the austenite changes into pearlite, leaving a conglomerate of pearlite and cementite. Thus steel, below a temperature of 600 deg. Cent., if it contains less than 0.90 per cent carbon, will consist of ferrite and pearlite, while if the carbon exceeds this percentage it will consist of cementine and pearlite.

The greater hardness of high carbon steel over mild steel is due, therefore, to the fact of its containing cementite, an intensely hard constituent.

The austenite is one of the hardest constituents of steel and is also very brittle. If the steel be gradually cooled this austenite changes completely into its constituents, but if the steel be cooled rapidly, as by plunging in water, the molecules have not sufficient time to arrange themselves, and thus the austenitic structure may be preserved to a certain degree. The more rapid the cooling the greater the consequent hardness due to the more complete preservation of the austenitic structure. By cooling at various rates we may obtain different degrees of hardness. For instance many steel articles are quenched from above the line *H F B* in oil, which does not cool them off as rapidly as water. Articles which require intense hardness, such as hack-saw blades, are quenched in cold water. They are then intensely hard, but brittle and partake of an austenitic structure.

Typical Views of Mississippi Levees.

The Control of the Mississippi Floods*

Reservoirs, Reforestration and Levees Each Have Their Uses

By Ch. D. Townsend, President of the Mississippi River Commission

THE subject of land drainage is intimately associated with that of river improvement. The cultivation of the soil largely increases the amount of sediment entering our streams; the direction of the furrow markedly affects the amount of rainwater that flows from its surface, and every ditch or subsurface drain promotes a more rapid flow into our rivers during floods and possibly affects their discharge during low water. On the other hand, no satisfactory system of land drainage can be accomplished in a country subject to periodic overflow by river floods. In the Mississippi Valley protection from floods is absolutely required before any regular system of drainage can be inaugurated. The overflow is so great and the amount of sediment carried by the river so large, that the drains would be annually destroyed or filled. The floods not only cause the destruction of any crops that might be planted, but also usually occur at such times as to prevent the harvesting of a second crop the same year. In a paper read before a levee convention in Memphis last September,[1] I briefly discussed the various means of flood control which had been suggested to the Mississippi River Commission. On the present occasion I propose to confine my remarks to the three methods in which the public appears most interested, i. e., reforestration, reservoirs, and levees.

SOURCES OF FLOODS.

Before entering upon such a discussion, it is desirable to have a clear conception of the sources from which floods arise.

You will recall, the greater Mississippi Valley is bounded on the east by the Appalachian Chain and on the west by the Rocky Mountains. These mountain ranges exert a great influence on its floods. The winds blowing from an easterly direction deposit most of the moisture they absorb from the Atlantic Ocean on the eastern slope of the Alleghenies, and therefore cause little rain in the Mississippi Valley; the Rocky Mountains intercept the moisture from the Pacific Ocean. While showers occur from winds blowing over the Great Lakes, the original source of the *floods* of the Mississippi is to be sought in the Gulf of Mexico.

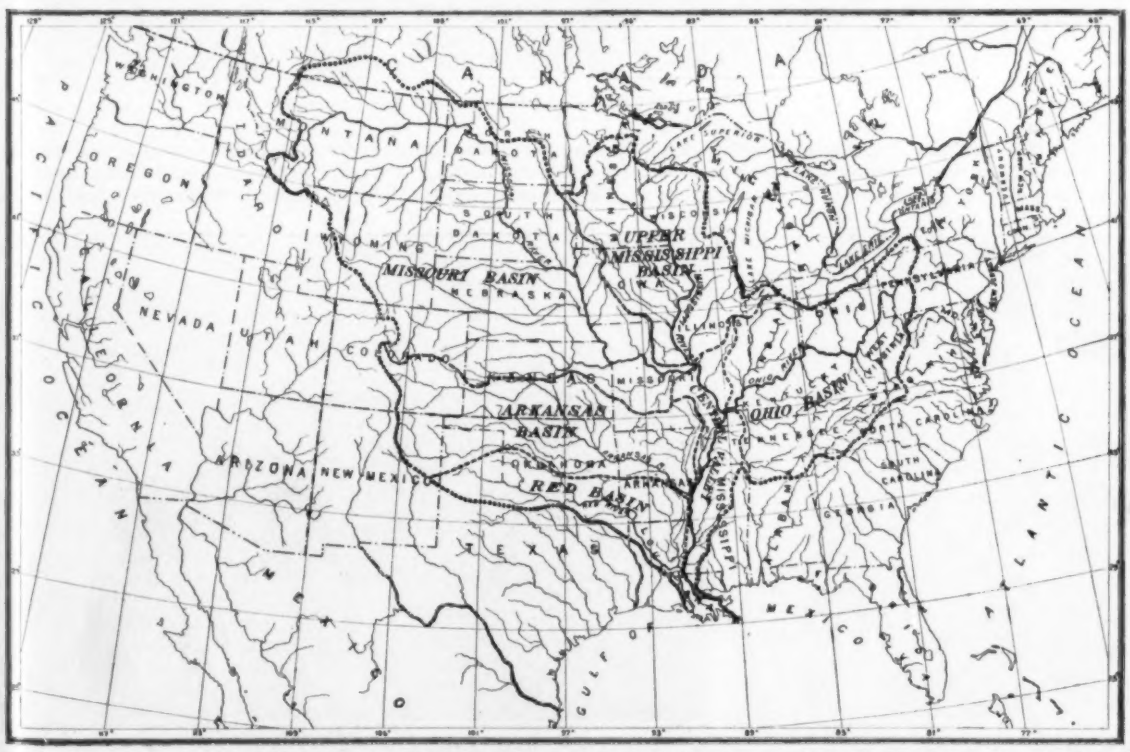
During the winter and spring the land of the Mississippi Valley, no matter what its soil or the nature of its covering, is cooler than the waters of the Gulf, and a southerly wind becoming saturated with moisture as it passes over the water will precipitate that moisture on the land in copious rains, or in snow when the temperature is sufficiently low. A wind from the southwest sweeps up the Ohio Valley; one from the south carries moisture to the upper Mississippi; one from the southeast to the valleys of the Arkansas and the Missouri: but in all cases there is a tendency for the greatest rainfall to occur near the coast, and gradually to decrease as the wind currents travel inland. Thus the average annual rainfall at New Orleans is 60 inches, at Memphis, 52 inches, at Cincinnati, 42 inches; at Pittsburgh, 36 inches; and at St. Louis, 40 inches. At the headwaters of the upper Mississippi it is but 25 inches, and at the headwaters of the Missouri but 13 inches. Though floods do not arise from mean conditions but from exceptional rainfall when six to ten inches fall in a week, these figures are good indices of flood volumes, as we find from observation by the Geological Survey at Williston, North Dakota, that the flood discharge of the upper reaches of the Missouri is about one second-foot per square mile of drainage area; measurements at St. Paul give an extreme flood discharge for the upper Mississippi of slightly over two second-feet per square mile. In the Ohio it is about six second-feet, and in the Ouachita, St. Francis and Yazoo rivers from eight to ten.

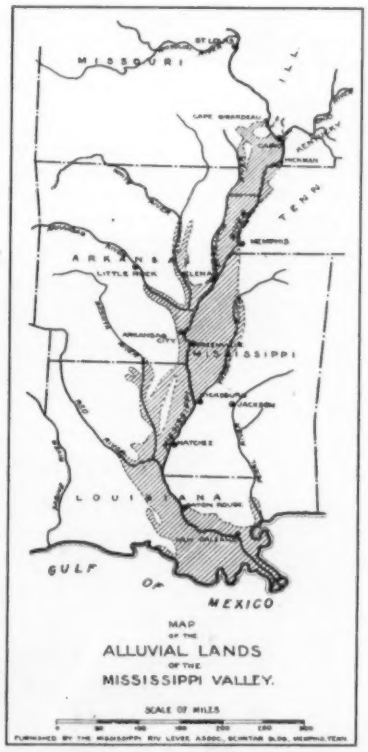
From this it will be seen that the rainfall is very unequally distributed over the Mississippi Valley, being least at the upper sources of the tributaries, and rapidly increasing as you approach the main stream, though an exception is to be noted in the southern tributaries of the Ohio, whose sources are nearer the Gulf than are their outlets.

The maximum discharge of the upper Mississippi River is estimated at 450,000 second-feet; the Missouri, 900,000; the Ohio, 1,400,000; the Arkansas, 450,000; and the Red, 220,000. There is also a large discharge from the Yazoo, St. Francis, White, Tensas, and Ouachita rivers. The maximum discharge of the Mississippi during the flood of 1912 was about 2,000,000 second-feet at Cairo, and 2,300,000 at the mouth of Red River. It overflows its natural banks when the flow exceeds 1,000,000 second-feet.

* Address delivered before the National Drainage Congress.

[1] Published in SCIENTIFIC AMERICAN SUPPLEMENT, January 4th, 1913.





The Drainage Basin of the Mississippi River, Which Embraces Thirty-one States, 41 per cent of the Entire United States.

Water from the Mississippi Rushing Through a Break in a Levee at High Water.

REFORESTRATION.

While the influence of forests on streamflow has received little attention in this country until recently, the scientists of Europe have discussed the subject pro and con during the past forty years. It is generally accepted by both sides that the leaves falling from forest trees as they decay form a humus which has a large capacity to absorb water, and that when the forests are felled this humus is seriously injured by forest fires. It is also admitted that snow is more rapidly melted when it is exposed to the direct rays of the sun in an open field than when sheltered from such action in a forest. In fact it has been found by the United States Forestry Service from experiments recently made in the White Mountains that the flow from cleared fields under such conditions is about twice that from forests. The forest advocates claim that this is sufficient proof that forests absorb water during flood periods which percolates through the ground and flows from springs later in the season, thus reducing flood heights and increasing the low-water flow of rivers. Its opponents do not admit that the problem is thus easily solved. They claim that floods do not arise from the melting of snows by the direct action of the sun; that this process is so slow that the water which flows off would not raise a river to mid-stage; that floods occur when on a layer of snow there falls a copious supply of rain, and both the rain and melted snow enter the stream simultaneously; and that under such conditions, the forest instead of being beneficial is injurious.

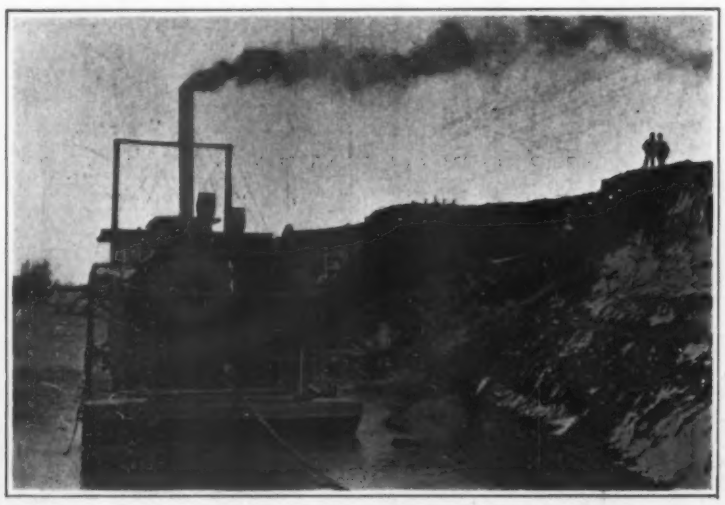
Lake Charles, Missouri.

On cleared land the wind tends to blow the snow from the ridges and pile it in immense masses in the ravines, while in the forests the snow is uniformly distributed. A few days of sunshine dries out the ridges in the open field and melts sufficient snow in the forest to saturate with water the underlying humus.

If a heavy rainfall then occurs, the forest humus being saturated can absorb no more water and the combined rain and snow of the forest flows into the streams, while in the cleared land the ridges having dried out absorb a large portion of the rainfall, and the snow-drifts expose a much smaller surface to the action of rain. Moreover, during periods of great drought, the forest humus and long deep tree roots also absorb more water than grass and farm crops, and retard the run-off at a time when it is most needed for low-water navigation. They therefore maintain that a forest is a fair-weather friend of some use in regulating the mid-stages of a river, but an utter failure when most needed, that is, during extreme floods or extreme low water. While I consider this discussion valuable, my objections to reforestration are not based solely on a scholastic argument.

It requires from twenty to fifty years to produce a good forest growth, and over a century for the leaves of that forest to decay in sufficient quantities to produce the humus which will be satisfactory as an absorbent of rainfall. We can not afford to delay the drainage of the Mississippi Valley, even to produce the forest growth,

Upper End of Kempe Bend, La.



Grading a Bank on the Missouri River With Hydraulic Jet Preparatory to Revetment Work.

Caving Bank in a Bend of the Mississippi. A Willow Mattress is Being Sunk to Prevent Erosion.

One of the Nine Hydraulic Dredges Used in Maintaining a Nine-foot Channel in the Mississippi River Below Cairo.

without taking into consideration the time required for the humus to form. We are more vitally interested in the height that the river will attain in the next few weeks than in what will occur in the year 2013.

Arkansas City, Ark.

It is also pertinent to this discussion to determine what would be the extent of the forest reservation which would be required to reduce the flood heights on the Mississippi River a given amount. To solve this problem it is necessary to make certain assumptions, and for purposes of argument we will take it for granted that reforestration will reduce the flood discharge of a stream one half. The Mississippi flood of 1912 attained the greatest height of any then recorded at all gage stations except at Vicksburg. That of January and February, 1913, while five feet lower at Cairo, was the next highest flood at Memphis, and for a considerable distance along the river. We will endeavor by reforestration to reduce the flood of 1912 to the heights attained in the winter of 1913. For this purpose it will be necessary to reduce the maximum discharge of the river 500,000 second-feet. It will also be necessary to distribute this reduction among the tributaries, reducing the maximum discharge of the Missouri River from 900,000 to 700,000 second-feet, that of the upper Mississippi from 450,000 to 350,000, and that of the Ohio River from 1,400,000 to 1,200,000.

As stated in the introductory remarks, the flood discharge of the Missouri River at its headwaters is about one cubic foot per second per square mile of drainage area, and if the reduction in discharge of one half is to be secured by reforestration, two square miles of forests would be necessary for every second-foot of reduction of flood discharge, or 400,000 square miles of forests to reduce the discharge of the Missouri River 200,000 second-feet. At the headwaters of the upper Mississippi, the ratio of flood discharge to drainage area is about two second-feet per square mile. A reduction of this discharge by one half would require a forest reservation of 100,000 square miles to reduce the floods of the upper Mississippi 100,000 second-feet. On the Ohio River the ratio is six to one, and it would therefore require forests at the headwaters of the Ohio having an area of 66,000 square miles to reduce its flow 200,000 second-feet. In other words, to reduce the height of a flood at Memphis by reforestration at the headwaters of the river from that of 1912 to the next highest on record, would require a forest reservation of about 566,000 square miles, an area exceeding that of the portions of Montana and Wyoming drained by the Missouri River and the states of North and South Dakota, the portion of Minnesota drained by the upper Mississippi River, and the states of Iowa, Wisconsin, Illinois and Indiana. But even such a forest reservation would afford only partial protection, and large expenditures for levees would still be required. Under the above assumptions, to prevent any overflow by reforestration would necessitate a practical abandonment of the valley for agricultural purposes, and the development of an extensive irrigation system to produce tree growth in the arid regions of the West.

Salem Crevasse, Miss.

Weaving Mats. These Measure up to 1,000 feet by 250 feet.

View of Gasconade Boatyard, Concrete Revetment.

It is therefore apparent that even under the most extravagant claims of forestry advocates, reforestration as a means of reducing flood heights on the Mississippi River requires the conversion of too much farming land into a wilderness to be practicable. The waste land that can profitably be converted into forest reservations is too limited in area to produce an appreciable effect on the floods.

RESERVOIRS.

To have retained the Mississippi flood of 1912 within its banks would have required a reservoir in the vicinity of Cairo, Illinois, having an area of 7,000 square miles, slightly less than that of the state of New Jersey, and a depth of about 15 feet, assuming that it would be empty when the river attained a bank-full stage. If the site of such a reservoir was a plane surface, the quantity of material to be excavated in its construction would be over 100,000,000,000 cubic yards; and its estimated cost from fifty to one hundred thousand million dollars. Such a volume of earth would build a levee line 7,000 miles long and over 150 feet high.

Cairo is the logical location for a reservoir to regulate the discharge of the lower Mississippi. It will not only control the floods from the Ohio but also the discharge from the Missouri and upper Mississippi. But if the reservoirs be transferred from the mouths of the tributaries to the headwaters, their capacity must be largely increased. No two floods have the same origin unless they are referred back to the Gulf of Mexico. The wind bloweth where it listeth. If the prevailing winds in the early spring are from the southwest, the southern tributaries of the Ohio furnish the crest of the year's flood; if more nearly from the south, reservoirs will be required on the streams of Ohio, Indiana, and Illinois; a slight varying of the wind will produce a flood in the upper Mississippi, while if it blows from the southeast the principal sources of trouble will be the Red, Arkansas, and Missouri rivers. To control the flow of every stream in the Mississippi Valley by reservoirs is a pretty large job, even for the United States Government, but that is what the control of the Mississippi during floods by reservoirs signifies.

The advocates of the control of the floods of the Mississippi by reservoirs do not, however, have in mind any such radical control as is above indicated. They limit the control to the headwaters of the various tributaries: and while every stream that flows in the valley may be considered a headwater of some tributary, I judge from the discussions of the reservoirs and their proposed employment for power purposes, which requires a considerable height of dam, that by headwaters is meant the sources of the rivers in mountainous countries as distinguished from the more level plains, and more specifically the sources of the Missouri above the mouth of the Yellowstone, those of the upper Mississippi in the State of Minnesota, and those of the Ohio in the Appalachian Range.

The flood which has recently devastated the country affords data for determining the effect of such a system of reservoirs and its lessons are the more valuable because no effort is necessary to refresh the memory. When on April 2nd the gage at Cairo attained a height of 54 feet there was flowing by it down the Mississippi River at least 2,000,000 cubic feet of water per second. It requires about eleven days for a flood wave to be transmitted the 966 miles between Pittsburgh, Pennsylvania, and Cairo; on March 22nd the Pittsburgh gage read 5.3 feet, which is produced by a flow in the Ohio River at that locality of about 15,000 second-feet. In ten days a flood travels the 858 miles between St. Paul, Minn., and Cairo; on March 23rd the reading of the St. Paul gage was 0.5 foot corresponding to a discharge of the Mississippi of about 2,500 second-feet. In eight days the effect of a flood at St. Joseph, Mo., is felt at Cairo; on March 25th the gage at St. Joseph read minus 0.1 foot, representing a discharge of the Missouri River of about 17,000 second-feet. If a system of reservoirs had been constructed which would have prevented all flow from the Allegheny, the Monongahela, the Mississippi above St. Paul, and the Missouri above St. Joseph, it would have reduced the 2,000,000 second-feet discharged by the Mississippi River at Cairo on April 2nd less than 35,000 second-feet.

The water which passed Cairo on the 2nd of April came principally from the White and Wabash and the lower tributaries of the Ohio, and after the water of these rivers started to subside, the flood from Cincinnati, though increasing from 57 feet to 69 feet on the gage, could increase flood heights at Cairo less than one foot. The flood of 30 feet at Pittsburgh on March 28th produced its effect on the Cairo gage day before yesterday (April 8th). It has prolonged the flood without increasing its height.

The proposed system of reservoirs would have cost hundreds of millions of dollars and its effect on this year's flood height of the lower Mississippi could not possibly have exceeded six inches.

Neither the rain nor snow which falls upon the mountainous portions of the Mississippi watershed has much effect upon the floods of the lower river. The principal source of the floods is the great alluvial plain between the mountains. As I have pointed out, excepting the southern tributaries of the Ohio, the rainfall is relatively slight at the upper sources of the tributaries and their maximum flood discharge does not usually coincide with that of the mid-valley.

Great floods do not arise from average conditions, but from exceptional variations such as are caused by a series of heavy rains rapidly succeeding one another. Each rainstorm starts down a stream—a flood—the volume of which can be absorbed by a reservoir with comparatively little trouble, but if a second storm sweeps over the valley, the reservoir to be effective must be emptied or its capacity doubled. To hold all the excess rainfall till low water, would require reservoirs of enormous capacity. Economic considerations usually require that the reservoirs should be emptied as soon as the crest passes, in order to utilize the same space for a second rainfall; so that while reducing the crest of a flood at a given locality, they necessarily prolong the period during which the river remains at a high stage.

The water which is abstracted from the Gulf of Mexico is usually precipitated in the Mississippi Valley within a period of two days. The return flow extends over a period of two or three months. The sum of the maximum discharges of the various tributaries of the Mississippi River is nearly 4,000,000 second-feet, while the greatest measured discharge of the river itself is about 2,300,000. This apparent discrepancy arises from the fact that the floods of the tributaries do not reach the Gulf at the same time. The crest of the Ohio River flood usually passes down the river in March or April, that of the Missouri in May or June. Moreover, the same law applies to the tributaries of a tributary. The waters of the southern branches of the Ohio tend to discharge into that river before those in Ohio, Indiana, and Illinois.

By the construction of reservoirs this beneficent law of nature is deranged. Instead of the crest of the flood of one stream passing down the river before that of another reaches it, two prolonged high stages will obtain, which will tend to synchronize, and the resultant combination may be higher than either flood would have been by itself.

A system of flood control designed to be satisfactory for one city may be most disastrous to another locality farther downstream. If a system of reservoirs had been in operation in the Allegheny and Monogahela rivers during last January, it would have protected Pittsburgh from overflow and diminished the flood at Cincinnati when it was 50 feet on the gage, but only to increase it when it attained a height of 60 feet. And this effect would have been propagated to the Gulf.

Pittsburgh, moreover, would never consent to such a manipulation of reservoirs on the upper tributaries of the Ohio as would insure the reduction of floods at Cincinnati or on the lower Mississippi. Source-stream control on the Mississippi River and its tributaries would, therefore, soon reduce itself to the question whose ox is to be gored.

LEVEES.

While the use of forests or reservoirs as a means of flood control is still in an experimental stage all over the world, the employment of levees for this purpose has been tested for centuries. The Po, Rhine, Danube, Rhône, and other rivers of Europe have been successfully leveed. The laws governing the flow of water in a confined stream have been carefully studied and the construction of levees is just as susceptible of mathematical analysis as other engineering problems. There is an element of uncertainty in all the forces of nature. No one can say positively, for instance, that St. Louis may not at some future time experience an earthquake, or a cyclone of greater intensity than that which swept over the city in 1896. There is also a possibility that there will be some combination of meterorological conditions which will create a flood of greater volume than has heretofore occurred in any drainage area. But the height to which levees should be constructed is as susceptible of determination as the strains to be permitted in an office building due to wind pressure or the moving load allowable on a bridge. The city engineer solves a similar problem whenever he constructs a sewer to carry off the storm water from the city streets.

Nor is there any evidence either that floods have been increasing in recent years due to the cutting off of forests or that the beds of our main rivers are rising as they are leveed. The effect of forests on rainfall in Europe has been carefully investigated by Professors Schlichting and Hagen. The records at London, Paris, St. Petersburg, and other localities where the rain has been recorded for long periods, fail to show any tendency to an increased fall in recent years.

The meteorological records of the United States have not been maintained a sufficient length of time to be of much value in solving the problem. Such data as we possess indicate that the flood discharge has not increased in recent years. The greatest flood of the Mississippi at St. Louis occurred in 1844, the next largest in 1785. On the great lakes the high water of 1838 is the greatest on record. In the Ohio the flood of 1884 exceeded that of 1913 at Cincinnati, and that of 1832 while 5 feet lower at Cincinnati was 5 feet higher at Pittsburgh than this year's flood. The gage records at the bridges over the upper Mississippi which cover a period of thirty years would indicate that the flow from Minnesota and Wisconsin, where the forests have been most extensively destroyed during the period, has been slightly improved, though the river shows signs of deterioration where it receives the flow from the prairie lands of Iowa and Illinois. They appear to confirm the conclusions of the German Forestry authorities that the influence of forests on drainage is concealed by other causes more powerful in their effects.

The flood of 1912 was not due so much to excessive precipitation as to the fact that the surface of the ground was frozen over the states of Illinois, Indiana, and Ohio, so that there was not the soil absorption of rain water that usually occurs.

There is not the remotest connection between deforestation and the disasters which have just occurred at numerous cities in Ohio and Indiana. The flood of 1832 was similar to that of 1913, but it was discharged by streams of the dimensions the Creator intended they should have. Since then cities have sprung up and land has become so valuable that riparian owners have encroached upon the waterways. Where the floods formerly flowed untrammeled, factories and dwellings have been constructed, and numerous bridges have further restrained the stream's discharge. When His laws are violated, though slow to anger, the Creator occasionally asserts his might and the works of man crumble before Him. If it would accomplish any useful purpose, I could name other cities where conditions are as dangerous as at Dayton or Columbus, but the lessons of the flood will be forgotten with the burial of its dead.

The question of the rise of the river bed by levee construction has been exhaustively investigated. On the Rhine the maximum effects were observed at Düsseldorf where the same discharge at low water appears to attain a height eight inches greater to-day than it did one hundred years ago, while the same discharge at high water has lowered about one foot in a century. On the Po, the maximum observed change in low-water conditions was 0.02 of a foot per year, but it is by no means proved that even these small changes have resulted from levee construction. They may have arisen from the improvement in the river bed which were made simultaneously with levee construction. The observations of the Mississippi River Commission agree with the Düsseldorf observations in that the Mississippi River appears to be slightly enlarging its section, at least at mid-stages.

The present contents of the adopted levee line of the Mississippi River is about 243,000,000 cubic yards. It has been computed that with an addition of 200,000,000 cubic yards and at an estimated cost of $57,000,000 this line would be safe against any flood which has occurred in the Mississippi River. This sum though large is less than $4 per acre of land protected from overflow, and appears insignificant when compared with the amounts which are being expended per acre for irrigation purposes in the arid West. The increase in the value of land or the damage caused by one overflow like that of 1912 would pay for the completion of the levee system.

When a levee line contains but one half the material that safety requires, crevasses afford no argument against levee construction. During the flood of 1912 hundreds of miles of levees were topped with earth in sacks to a height of from two to four feet, to prevent the water flowing over them, and water was seeping through their narrow bases in copious streams which was unheeded until mud began to flow. The levee which failed at Beulah, Miss., this winter was held till the pile of sacks exceeded twenty feet in height.

The holding of 1,526 miles of such levees through the flood of 1912, even though 13 miles failed, is a powerful argument in favor of a properly constructed levee line. There was no failure where levees were built to a suitable grade and adequate dimensions, as in the upper Yazoo District.

CONCLUSION.

While of the opinion that levees afford the only practicable method of controlling the floods of the Mississippi River, in conclusion I desire to state that I am strongly in favor of both reforestration and reservoir construction, but limited to the purposes for which they are adapted, just as I am in favor of reinforced concrete for small bridges though not considering it applicable to one spanning the lower Mississippi River. The price of lumber to-day is a sufficient argument for planting trees, without attempting to associate forestry with the climate or with the flood conditions on our rivers. If the Federal government or the states do not conserve the forests, the time will soon come when the farmer will raise his crop of timber just as now he plants a field of wheat, and for the same reason, because it will pay him to use his waste land for the purpose.

Reservoirs are necessary for municipal water supplies,

*Reproduced from Engineering Record.

for purposes of irrigation, for the development of power, and for feeders to canals. They can be successfully employed on small streams to diminish floods or increase the low-water flow. The trouble arises when an attempt is made to utilize them for too many purposes at the same time. There must be a paramount issue to which the others will be subsidiary.

If the main purpose is to supply a city with water only the excess can be used for power development. If the dams are constructed to produce power, the reduction of floods and the improvement of river navigation must be subordinate thereto. Water required for irrigation can only be used to develop power when the dam of the storage reservoir is given a greater height than is necessary for its flow over the land to be reclaimed.

During the next decade there will be an enormous development of reservoirs both for irrigation and for power purposes, which I hope will be utilized to correct man's folly and prevent many disasters similar to those which have recently occurred in Indiana and Ohio. While the control of the lower Mississippi by reservoirs is impracticable there are numerous smaller streams where they can be used with excellent results.

It is questionable, however, whether such reservoirs should be built with the control of our rivers the first object of consideration. It will, to be sure, saddle the cost on the United States Treasury, but to close down a power plant and stop the growth of crops every time the navigation of a minor stream is interfered with, I do not consider would be a wise proceeding.

I am also skeptical of government ownership. It may have worked satisfactorily in irrigation projects, but my own experience with government ownership of water-power makes me suspicious. I have found that when the government buys water-power, the power companies consider it worth $25 per horse-power per year, but when conditions are reversed and an attempt is made to lease it, the price drops to 10 cents.

Wherever it will pay to build a dam for power purposes, capital stands ready to construct it, if it can obtain the franchise. By regulating the franchise, the reservoir can also be used to restrain local floods.

The systematic conservation and regulation by the Government of a river from its source to its mouth sounds most attractive, suggesting a scientific solution of every problem of river hydraulics, but I greatly fear that it is the voice of a siren luring the people to an open pork barrel for every stream in the United States.

Electric Lamps for Miners*

Recent Improvements Received from England

In the last two years great progress has been made in the development of electric lamps for miners, and invention was undoubtedly stimulated by the offer through the Home Secretary of prizes to the value of £1,000 for a suitable apparatus. The use of the metallic filament lamp, with its smaller current consumption, and of a single accumulator cell, which the metallic filament renders possible, has greatly simplified the problem, while by the employment of a single cell the intermediate connection between the two cells has been eliminated and with it a frequent source of trouble.

THE ACCUMULATOR.

Great improvements have been made in the accumulator itself. The experience of manufacturers of accumulators for motor ignition outfits has been of great value to those who have been working at the miner's lamp problem. The vessel containing the battery is cylindrical in some lamps, and square in others. In three of those which received prizes in the recent adjudication, the batteries are cylindrical. This form is necessarily the strongest; it presents fewer chances of the metallic containing case itself being damaged by chemical or electro-chemical action, and there are few points where acid can lodge. In some of the batteries the plates themselves are flat, in others they take the form of a portion of a cylinder, as in the lamp which obtained the £600 prize. For this latter it is claimed that the battery will stand very heavy discharges, such as would arise if a short circuit occurred, and that the construction of the battery plates themselves is such that the occurrence of an internal short circuit is almost impossible.

In some of the batteries an absorbent is employed to prevent internal contact between the battery plates, in others protection is obtained by other means. In the lamp which won the £600 prize the plates are wrapped with a strip of asbestos paper, outside of which is a thin wrapping of glass wool, the whole being held in place by thin bands of pure rubber, with a clear space between the plates. It is claimed that this arrangement is better than the use of an absorbent, which must be more or less uncertain in its action. During the fifteen or sixteen years it has been employed in Murton Colliery, County Durham, it has answered very fairly.

In all the batteries celluloid is employed for the containing vessel. That material is a fairly good insulator, can be molded, will stand a certain amount of rough usage, is not attacked by the dilute sulphuric acid employed, and is generally suitable.

One important matter in connection with secondary batteries employed in miners' lamps is, on the one hand, the prevention of the egress of acid, and, on the other, the provision for the egress of the gas which may be generated in the working of the battery. No gas should be emitted from the electrolyte while the battery is discharging. Gas, however, is generated somewhat freely at the end of the charging process; and as water dissolves nearly all gases, it may happen that a certain quantity of the gas formed at the end of the discharge remains dissolved in the liquid, and comes away afterward. For such a case provision is made by special stoppers in some cases, and in that of the lamp which obtained the £600 prize, by an arrangement which is very ingenious, if somewhat delicate. By the combination of a celluloid tube, about three fourths of an inch in diameter, inside the positive plate with an inner capillary tube, any gas which is present in the liquid, and which bubbles free when the lamp is in use, is allowed to pass out through the capillary tube into the outer case, and, when the case is opened, to the atmosphere; but the egress of acid is prevented. The object is, of course, to prevent the leakage of acid, should the lamp be laid on its side or inverted. The presence of an accumulation of gas inside the cell would have a bad effect upon its working.

THE CONTAINING CASE.

Several inventors are employing cylindrical cases, and all of them are using very much stronger cases than was customary in the older lamps. In the early Sussmann lamps the tinned iron containing cases were very thin and were quickly eaten away when a little drop of acid was spilt on them. These cases were very cheap; but this is one of the instances where cheapness is unwise. The additional cost of the stronger and heavier cases employed by later inventors is trifling compared with the cost of the remainder of the lamp, but the increase in the chances of successful working is great. At its best the electrical accumulator is a delicate apparatus; and though celluloid as employed in modern accumulators is fairly strong it is the better for receiving all the protection that can be provided for it. In two or three of the recently introduced lamps special provision is made for protecting the celluloid containing vessel of the accumulator from shocks, say, when the lamp is knocked against a pit prop or a mine wagon. The method employed is to form a projection on the bottom of the celluloid containing vessel and a recess in the bottom of the metallic containing vessel. The projection upon the celluloid vessel fits into the recess in the outer containing vessel, and the usual arrangement is that a small air space is left between the two vessels, so that the force of any blow the outer case may receive is not handed on to the battery.

Inventors differ as to the metal of which the outer containing vessel should be composed, and as to the best form to give the greatest amount of security to the battery inside. Some employ aluminium, principally because of its lower specific gravity. The majority, however, prefer stout galvanized iron, and in the lamp which won the £600 prize horizontal corrugations are formed in the case. There can be hardly any doubt that these corrugations are of considerable value. During the tests to which the lamps submitted for competition were put, this lamp in particular was frequently thrown violently upon a stone floor without even extinguishing the light.

LAMPS AND CONNECTIONS.

Great advances have been made in the arrangement of the incandescent bulb, the method of protecting it, and the method of connecting it with the battery and with the switch. All of the lamps on the market have a switch. In the earlier forms the switch was almost the weakest part of the apparatus. The space available for it was so small and the conditions generally were so severe, that it easily got out of order. In the later forms the switch is much simpler than was possible where two cells were used, and it is also made more strongly. In several of the lamps there is a rubbing contact, so that any dirt left by a spark when the circuit was last opened is rubbed off in closing the circuit the next time the lamp is switched on.

The mechanical connection between the cover, which carries the incandescent lamp, and the switch, etc., has been much improved. In at least two forms of lamp, the upper edge of the containing metallic case is secured to a strong metallic ring, upon which the cover sits and to which it is locked by some arrangement that is not easily opened by the miner. In the lamp which secured the £600 prize, a magnetically-locked bayonet joint is used. Other lamps employ the device, which is very general in lamp rooms, of locking by means of a lead rivet, upon which is impressed a stamp. The glasses protecting the incandescent lamp itself have been strengthened, and an inverted cup-shaped glass is used, in some lamps, in place of a plain cylinder. In one case the cup is made to perform the double office of protecting the incandescent lamp against mechanical injury, and of maintaining the connections between the lamp and battery in good condition. If the protecting glass is broken, the current is cut off from the filament of the lamp. This is accomplished by the aid of two springs, one above the incandescent lamp, inside the protecting globe, and the other surrounding the central contact pin of the lamp. The combination of these two springs has another very important and useful effect, for it has been found to lengthen the life of the incandescent lamp.

As regards the connections between the battery and the incandescent bulb a new departure was made in the lamp which won the large prize. The actual connecting terminals of the battery are loose. They consist of small pins surrounded by spiral springs, the pins fitting into slots in the heads of the terminals of the accumulator plates, and the contact heads carried by the spiral springs being forced up against contact plates on the under side of the cover. When the lamp comes into the lamp room, the cover is removed, and these pins are also removed and thrown into a basin of hot water. Experience has shown that no matter what care is taken the connecting pieces have a small quantity of acid spilt over them, and that the simplest method of meeting this trouble is to wash off the acid before reissuing the lamp.

THE DETECTION OF GAS.

So far no gas detecting apparatus suitable for fixing upon portable miners' electric lamps has been placed upon the market. Several attempts have been made to produce one, and in one case in particular the results were apparently very good indeed, percentages so small as one fourth per cent being detected, and clearly noted upon a dial. Unfortunately the experiments that were made in working out the details of the apparatus were conducted with town illuminating gas, under the impression that it was the same as the gas found in coal-mines. Methane, the gas found in coal-mines, is indeed a large component of ordinary town gas, but the latter also contains in the neighborhood of forty per cent of hydrogen, and this gas is much more sensitive to the conditions under which the detector worked. All inventors of detector apparatus have employed the catalytic property of platinum, though the apparatus that have been worked out differ very much in their arrangement. None produced so far has been found sufficiently sensitive to indicate the percentages of the methane alone, as found in coal-mines, while they are also sensitive to other gases, such as carbonic oxide and sulphureted hydrogen.

*Reproduced from the Engineering Supplement of the London Times.

The Mechanism of Animal Behavior

It is a matter of some dispute just to what extent the actions of animals are determined by pure unreasoning instinct. It has been stated that a frog will snap at any small moving object, regardless of its character, and regardless of hunger or satiety. Some experiments carried out by A. A. Schaeffer seem to indicate that the frog is capable of greater discrimination than had been credited to him. Thus for example a frog was offered hairy caterpillars, which it promptly seized, and with equal promptness spit out again. But after about from four to seven such injudicious attempts the frog had learned his lesson, and thereafter refused similar fare. In another experiment earthworms were so connected with a source of electricity that the frog received a shock on touching the worm. The frog duly devoured the prey, and showed no signs of discomfort. However, he refused for seven days to touch another earthworm, while he freely devoured other species of worms. Similarly, the frog could be taught to avoid worms on which oil of cloves or calcium chloride had been spread, although such "doctored" prey was not spit out, but only digested.—*Kosmos.*

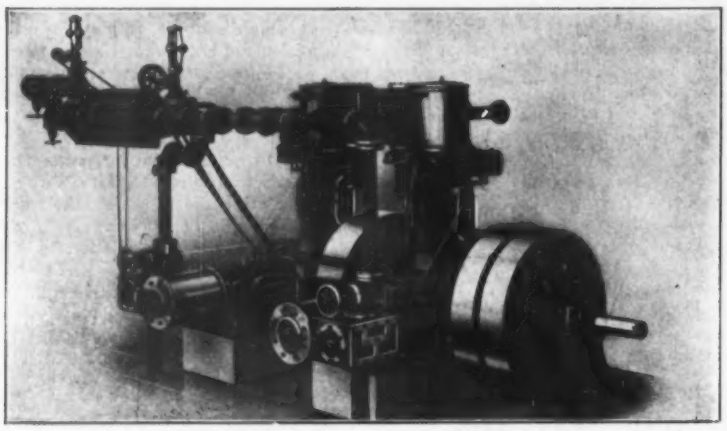


Fig. 1.—Four-cylinder Variable-speed Paper Mill Engine. This Engine has Two Horizontal and Two Vertical Cylinders and Operates at a Wide Speed Range of Eight to One.

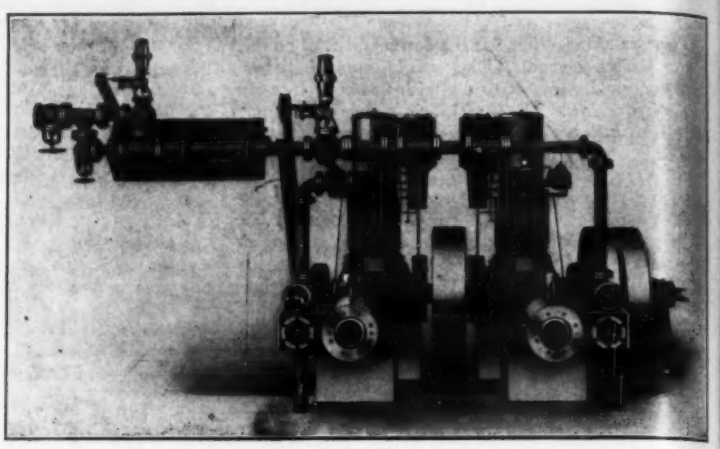


Fig. 2.—Another View of the Four-cylinder Paper Mill Engine. Owing to Its Wide Speed Range, This Engine May be Coupled Directly to the Variable Speed Shafting.

A New Paper Mill Engine

Wide Speed Range Secured by Special Designs

THE fundamental requirements of a variable speed paper mill engine are a speed range equivalent to the desired speed range of the rolls, and secondly as near as possible perfect regulation at all speeds.

The usual type of paper mill engine has two horizontal cylinders with cranks at an agle of 90 degrees. The range of speeds obtainable with an engine of this type is limited, because the unbalanced reciprocating forces prohibit operation at high speeds and because below a certain speed the turning effort becomes uneven and the fly-wheel less effective in evening out the speed, thus setting a lower limit below which regulation is seriously impaired. An engine of this type would have speeds from say, 75 to 300 revolutions per minute, depending on the size, giving a range of 4 to 1.

Where a wider speed range is wanted some form of speed change gear must be placed between engine and shafting. The simplest gear is a belt and pulley arrangement, and this in connection with two cylinder engines has proved a reliable paper mill drive. A drawback, however, is that the arrangement of pulleys and belts complicates the plant, consumes power, increases attendance and maintenance and that time is lost in changing speeds. Ordinarily it requires from one to two hours to change over from one pulley to another, and since it is necessary to shut down the plant while doing this, there is a loss of output amounting to one or two per cent if the speed has to be changed say once a week.

THE INFLUENCE OF RECIPROCATING FORCES ON ENGINE SPEED.

The secret of engine design for wide speed range for paper mill drive is to arrange the cylinders of the engine and to design reciprocating parts and counterweights so that the reciprocating forces are neutralized and perfect balance is secured, thus permitting of running the engine at high speeds.

It is an erroneous impression that counterweights attached to the heel of a crank will neutralize reciprocating forces. As a matter of fact, a counterweight on a horizontal engine merely transfers the thrust from a horizontal to a vertical plane, thus causing a direct impact on the frame of the engine and on the foundations, instead of a sideways or lateral push. In slow speed engines, these unbalanced forces can be taken care of by heavy foundations and foundation bolts, and no serious trouble may occur. But since these forces increase as the square of the velocity of the reciprocating parts, a definite limit is soon reached beyond which the speed of an improperly balanced engine cannot be increased.

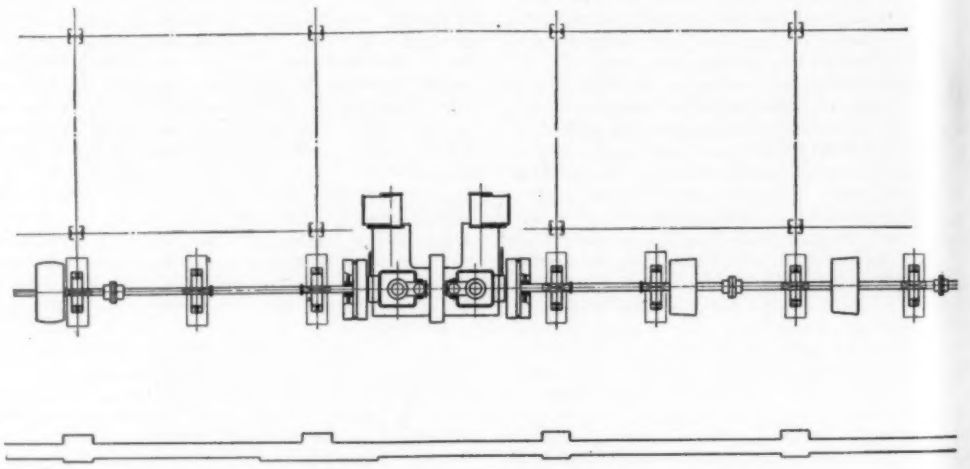


Fig. 3.—Four-cylinder Paper Mill, Engine, Together With Section of Variable Speed Shafting as Installed at a Hudson Falls Plant.

THE NEW FOUR-CLINDER PAPER MILL ENGINE.

The four-cylinder paper mill engine shown in Figs. 1, 2 and 3 is designed with four cylinders arranged in pairs of right angles. The engine is thus built of two units, each of which has a vertical and horizontal cylinder. Each pair of vertical and horizontal pistons drive a common crank-pin and there are eight power strokes per revolution evenly distributed 45 degrees apart. A counterweight on each crank transfers the horizontal reciprocating forces from a horizontal to a vertical plane, in which they meet equal and opposite reciprocating forces from the vertical reciprocating masses, which therefore neutralize unbalancing. This permits of operation at high speeds, a consideration which is of special importance in the class of work for which the engine is designed.

The balancing of this engine is so perfect that it may be operated at speeds of 400 to 500 revolutions per minute. Furthermore, owing to the perfect balancing and even turning effort the engine may be operated at a lower speed of 50 revolutions per minute with good regulation so that a total speed range of 8 to 1 and even 10 to 1 may be obtained. The engine may be

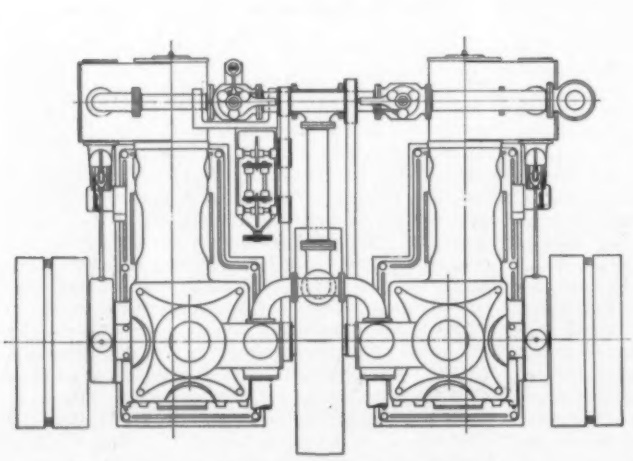


Fig. 4.—Plan of Four-cylinder Paper Mill Engine.

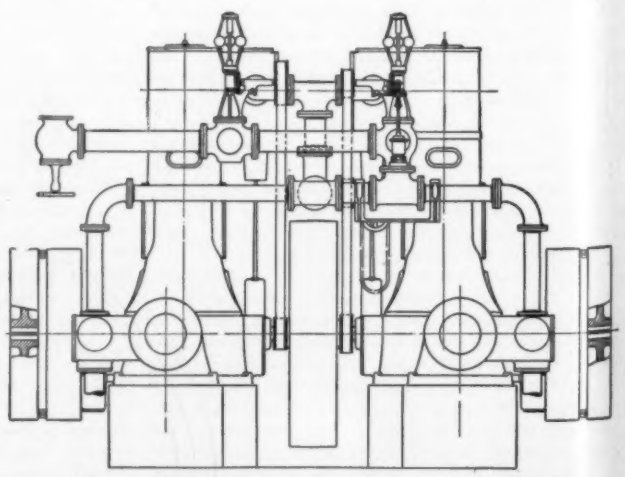


Fig. 5.—Elevation of Four-cylinder Paper Mill Engine.

Fig. 6.—Photograph of Four-cylinder Paper Mill Engine as Installed in a large Bag and Paper Plant, Hudson Falls, N. Y.

coupled directly to the line shafting and the delays, complications, space requirements, loss of power and other drawbacks of belt gearing between engine and shaft are eliminated. Fig. 4 gives a plan view of a four-cylinder engine as installed in a Hudson Falls plant, together with a section of the variable speed shafting, showing clearly the advantages of this type of drive. The photograph of Fig. 3 shows this engine as installed.

Fig. 7 shows a patent flexible coupling for paper mill engine drive. This is a coupling with belt lacing, but the lacing does not continue around the whole circumference of the two wheels. The pins are set in the edges of the wheel-rims in arcs of only 90 degrees, diametrically opposite. Therefore by simply removing the belt lacing and rotating either one of the wheels through an arc of 90 degrees, a section of the shaft may be lifted out without necessitating endwise motion of the shaft.

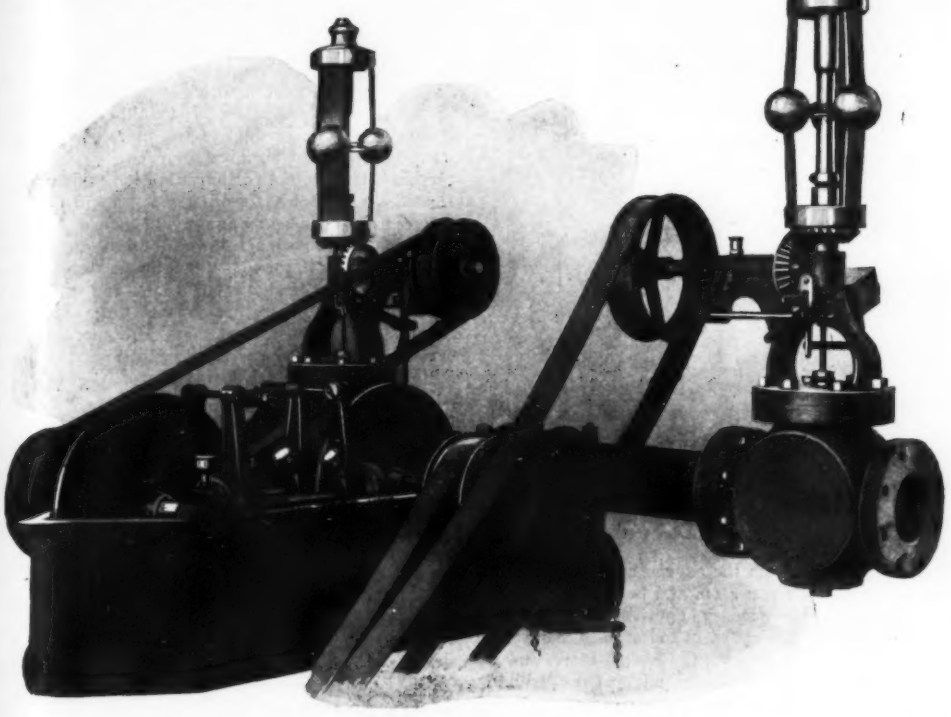


Fig. 8.—Ball Governing and Speed Changing Mechanism as Supplied With Paper Mill Engines. At the Left in the Rear is the Speed Governor Driven Through the Friction Device, and at the Right, the Automatic Engine Stop Driven Directly from the Engine.

SPEED CHANGE MECHANISM AND GOVERNORS.

The photographs of Figs. 8 and 9 show the speed changing and governing mechanism as used with the four-cylinder paper mill engines described above. The devices illustrated perform a number of important functions and, in fact, are a most important part of the whole engine equipment.

Two governors are used. Each of these governors is of a standard type, specially improved and adapted to this particular service. The first governor is the automatic engine safety stop and is placed nearest the steam supply pipe, being shown at the right in the photograph of Fig. 8.

As may be seen, this governor is driven by belt directly from the engine shaft and is fitted with an automatic tripping mechanism. The steam valve remains wide open throughout the whole normal range of speeds for which the engine is designed, but in case the speed exceeds the predetermined limit the mechanism is tripped and the weighted lever closes the steam valve. At all normal speeds this governor valve has no throttling effect whatever and hence cannot affect the engine speed.

The second governor, which may be seen to the left in Fig. 8 and to the right in Fig. 9, controls the engine speed and is driven through the variable speed friction device also shown.

The requirement of constant speed throughout a wide variation in speed, as for paper mill service, is a most difficult one to meet. When once the speed of the engine has been adjusted to give a certain grade of paper, the speed must stay constant, and must not be affected by variations in steam pressure or back-pressure which, with an ordinary governor will cause surges in speed or hunting and breaking of the paper.

To prevent such speed surges, a standard governor has been equipped with a mechanism comprising stabilizing springs and an oil pot, which may be seen in the photographs. The piston of the oil pot receives motion from the governor stem, through the spring stabilizing device, which absorbs shocks induced by sudden changes in speed of the governor balls.

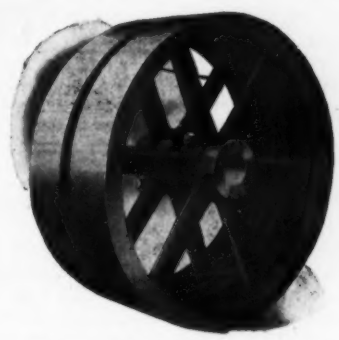


Fig. 7.—Patented Flexible Coupling, as Used for Paper Mill Drive.

This stabilized governor is driven from the engine through variable speed friction device of special design, which may be seen in both photographs. A belt from a pulley on the engine shaft drives a pulley on the friction device, which drives a second pulley through two disks and two pairs of friction wheels. Any speed from minimum to maximum may be imparted to the second pulley, which in turn drives the governor.

The two large iron wheels or disks are each keyed to a pulley shaft. Bearing on the surface on these disks are four small friction wheels, one on each side of each disk. The driving disk keyed to the shaft of the driving pulley rotates the two friction wheels held against it by springs, and the second pair of friction wheels drive the second disk and the pulley keyed to its shaft.

The speed is changed by simply shifting the position of the friction wheels, which are carried by four rockers located in pairs, each pair being held to a shaft which passes through guides and may be shifted as desired by a chain wheel and lead screw cut at one end. Each pair of rockers is held together by springs, thus keeping the friction wheels firmly against the disks. All bearings are of the ball-bearing type.

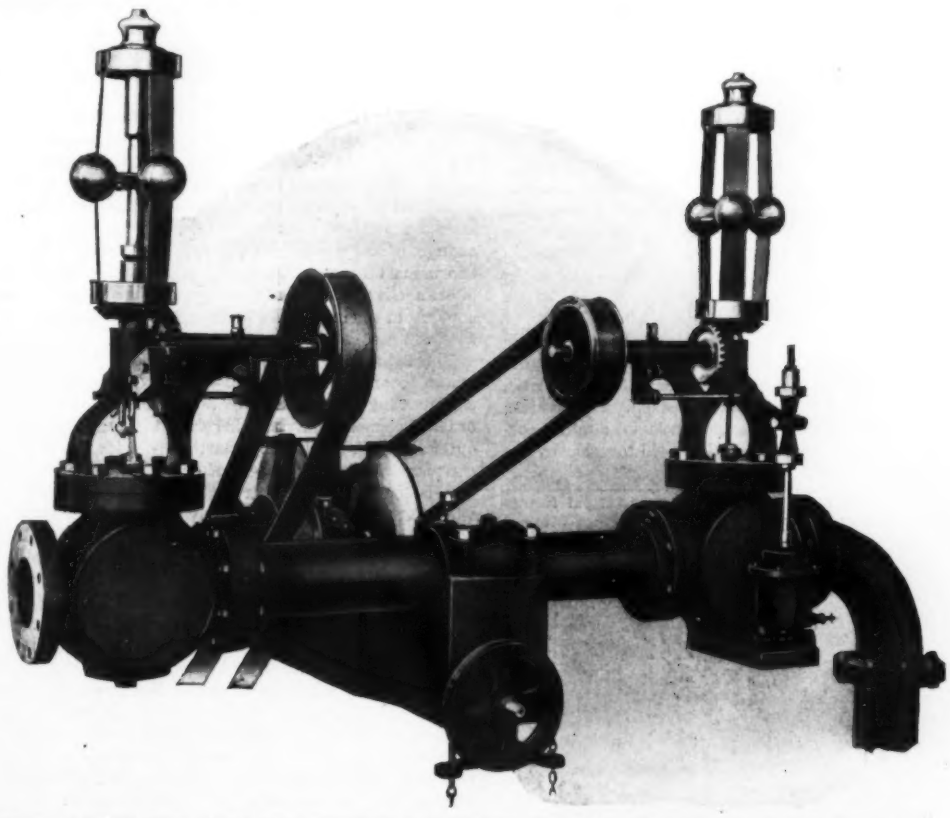


Fig. 9.—Another View of the Ball Governing and Variable Speed Mechanism; at the Left is the Automatic Engine Stop, and at the Right, the Speed Governor. Attention is Drawn to the Stabilizing Spring and the Oil Pot Which Prevents Hunting and Surging of Engine Speed.

A Flying Frog

THE name "flying" frog is something of an exaggeration. Still, a frog that makes bounds of some six feet deserves special recognition. The animal is a native of Java. Its systematic name is *Polypedates Reinwardti*. When performing one of its remarkable leaps it is distended with air and the toes are spread widely. When the frog alights the air cushion formed by its distended lungs takes up the shock which otherwise would be rather severe.

The Structure of the Atom—V*

The Physical and Chemical Properties of the Atom Explained in the Light of Modern Theory and Experiment

By Sir J. J. Thomson, F.R.S.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1947, Page 263, April 26, 1913

IN my last lecture I gave a sketch of a type of atom suggested by the results obtained in studying the discharge of electricity through gases. This type of atom was supposed to hold within it a number of corpuscles proportionate to its atomic weight. These corpuscles were packed into a mass of positive electricity. This held together, by its attraction, the corpuscles which tended mutually to repel each other. For the greater part these corpuscles were collected into the center of the atom, forming its core, while a smaller number, much more loosely held, were distributed near the outside surface. The whole of the chemical properties of the atom were supposed to depend upon these outside corpuscles, which were much more loosely attached than the corpuscles in the core.

The number of corpuscles in the outer ring determined the position of an element in the periodic series. If there were in this outer ring but one corpuscle, the element belonged to the first group, and was a monovalent electro-positive element. If there were two such corpuscles, the element belonged to Group II, and if there were three, to Group III, and so on.

I also showed that, from the conditions governing the equilibrium of mutually repulsive systems, there was a limit to the number of corpuscles which could be arranged in a ring, and be in stable equilibrium. This limiting number depended upon the nature of the force which held the system together, and there were chemical reasons for concluding that the force was such that eight was the maximum of corpuscles it was possible to have in the outer ring. If we took this view of the atom, it followed further that each atom had two valencies, according as it was associated with elements more electro-positive or more electro-negative than itself. The sum of these two valencies was always equal to 8 if this were, as assumed, the maximum number of corpuscles which could form a stable ring.

In continuation of last week's discussion, I wish to say a word as to unsaturated compounds in which the atoms are not arranged so as to satisfy the condition of constant valency. In studying this point it is necessary to consider not merely the maximum number of atoms that can form a group, but also to consider whether a smaller number might not arrange themselves so as to have but little residual attraction left. If this were the case, the compound would be stable, although some valencies were unsatisfied.

The difference between a free atom and an atom in combination is regarded as due to the negative corpuscles on the surface of a free atom being very mobile, so that they move round easily into positions which cause the atom to be readily attracted by other systems and with very considerable force. If the corpuscles are fixed, however, and no longer able to move, they can not adjust themselves to positions in which they would be attracted. Hence in a free atom the attraction is universal, but in a combined atom attraction will be developed only in certain very special positions. Anything which holds the surface corpuscles in a fixed position takes away from the atom its power of attracting other atoms, and will enable the system to exist without fixing other aggregations.

Carbon monoxide is a most flagrant example of an unsaturated compound. How, then, is the existence of this body to be reconciled with the theory of valency given in my last lecture? On the view there set forth, the carbon atom contained four corpuscles in the outer ring, and to fix these four more would be needed. This fixation might be effected by the four corpuscles of another carbon atom, the two atoms being then held together by the corresponding forces.

* Fifth of a series of Lectures delivered at the Royal Institution and reported in *Engineering*.

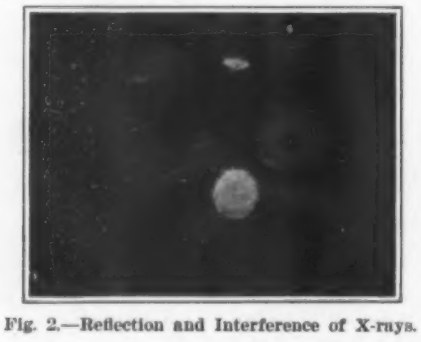


Fig. 2.—Reflection and Interference of X-rays.

The question to be considered is, however, whether it would not be possible to have a compound of carbon with oxygen, in which the two corpuscles of the latter held the four of the carbon, so that there was very little outside attraction. This, I think, is quite possible if the oxygen corpuscles are arranged so as to have a large stray field.

Fig. 1.

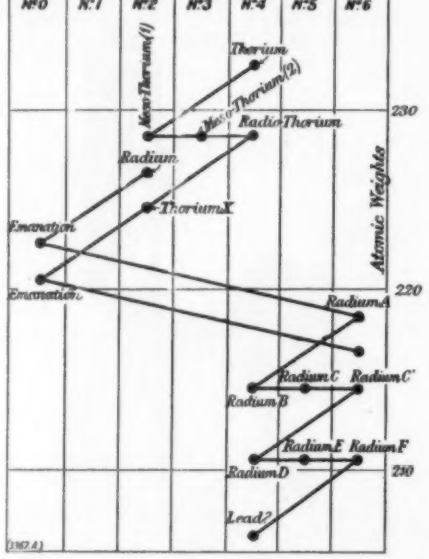


Fig. 1.—Arrangement of Elements in Natural Groups.

The forces emanating from the oxygen atom would then spread through the carbon atom and hold the four corpuscles of the latter in a quasi-rigid position. If the stray field, thus assumed, were sufficient to do this, the oxygen atom might be said to saturate the carbon atom, and a compound such as CO might exist and yet not exhibit any considerable attraction for further oxygen. In this way, I think, it would be possible to account for the existence of unsaturated compounds, and the fact of variable valency is brought into accord with the ideas set forth as to the constitution of the atom.

On this theory it is the corpuscles on the surface which hold the atoms together, and on them, moreover, all chemical properties are wholly dependent. The chemist, in fact, deals merely with the superficial properties of the atom, and if he desires to stir an atom to its depths, he must use physical means or go to the radioactive bodies.

These radioactive changes take place in the inner core. They are of two kinds. In the one an α particle is expelled, this α particle being an atom of helium carrying two positive charges of electricity. Such a change is known as an α-ray change. In addition there is the β-ray change, in which a negative corpuscle is expelled with an enormous velocity. The energy displayed in both types of change is so great that it proves that the particles must come from the inner core, and not from the surface of the atom.

This being so, what will be the effect on the atom if, for instance, an α particle is expelled? To fix our ideas, assume that the radioactive body belongs to the second order of elements, having, therefore, two corpuscles in its outer ring. From this an α particle is suddenly shot out, carrying with it two charges of positive electricity. The core is then left with a strong negative charge, and the whole atom will be accordingly negatively electrified. It can not stay so, but must get neutral. It does this by ejecting two corpuscles from its surface system, leaving none, and the atom thus passes into the group of helium, neon, argon, and the radium emanation. The loss of an α particle, therefore, is followed by a loss of two surface corpuscles, the latter change being equivalent to a drop of two in the order of the chemical group. Hence a second group element will drop to group No. 0, and a fourth group element to group No. 2, and so on. In the β-ray change, on the other hand, the expulsion of the negative corpuscle from the core leaves the atom positively charged, and it must, as before, get neutral. This it can very easily do by attracting into its surface a corpuscle of which there is always a plentiful supply. If then there were originally two corpuscles in this outer ring there will be three when the atom becomes neutral again after a β-ray change. Hence instead of losing two surface corpuscles, as in the α-ray change, the atom gains one in a β change. This gain will alter the chemical group of the element, taking it out of the first into the second, out of the second into the third, and so on.

Quite recently some most interesting work on the chemical properties of the products of radioactivity has been carried out. Soddy was, however, the first to call attention to the fact that the emission of an α particle always made a drop of two in the chemical grouping of the body concerned, and had pointed out later that there was evidence in favor of the view that the β-ray change caused, on the other hand, a rise in the chemical group.

In the *Physikalische Zeitschrift* of February 15th last, Dr. Fajans has followed out this point of view in the case of radium and thorium, and his results are indicated in Fig. 1. Here the ordinate represents the atomic weight of each successive product of the radioactive changes, and the abscissæ the chemical groups.

Radium is very like barium in all its "uninteresting" properties and belongs accordingly to group No. 2. The emanation is produced by an α-ray change, and thus this emanation is two groups below radium, belonging therefore to group No. 0, the elements belonging to which have no valency. The emanation next loses an α particle and becomes radium A. It has thus to drop two groups. Here it should be noted that the condition of no valency corresponds either to no corpuscles in the outer ring, or to eight corpuscles there. Hence a drop of two would bring radium A into group No. 6, as indicated in the figure. The change from radium A to radium B is another α-ray change, so that radium B belongs to group No. 4. In the next two changes β particles are lost. Each of these raises the order of the group by one, so that radium C belongs to group No. 5, and radium C_1 to group No. 6. The change from radium C_1 to radium D is an α-ray change, so that radium D belongs to group No. 4, and its atomic weight is four less than that of radium C_1. Following this are two β-ray changes, giving in succession radium E and radium F, the latter being identical with polonium. This is as far as the changes have, as yet, been traced, but it is supposed that there is an α-ray change which converts polonium into lead.

Taking the corresponding changes with thorium, this element belongs to group No. 4. The first change is an α-ray change to meso-thorium (1). This is followed by a β-ray change to mesothorium (2). There is then a second β-ray change to radio-thorium, which, as shown, belongs to group No. 4. An α-ray change now produces thorium X, bringing down the number of the group by 2. Thorium X, by an α-ray change, gives the emanation which belongs accordingly to group No. 0. This emanation then, by an α-ray change, passes to an element belonging to group No. 6, which is as far as the changes have, for the present, been traced.

The theory I have set forth makes it possible to predict the effect, on the chemical grouping of an element, of either an α-ray or a β-ray change. So far as the matter can be tested, experiment has verified these predictions. The changes, it is true, are difficult to follow, but the scheme above set forth is an agreement with the experiments so far as they go, the groups indicated by theory being the groups found by experiment. This, moreover, is not the only interesting point which follows if the atom is constituted as described.

Let us consider, for example, an α change followed by two B changes. The former means the loss of two corpuscles from the outer ring, but the latter the gain of two corpuscles An example of this is the series of changes from radium A to radium C_1. It will be seen that radium C_1 had as many corpuscles in its outer ring as radium A, and, so far as the chemist was concerned, the state of the inner ring is the same as before, so that, by chemical tests, radium A should be indistinguishable from radium C_1, and we might thus have two elements of different

Fig. 3.

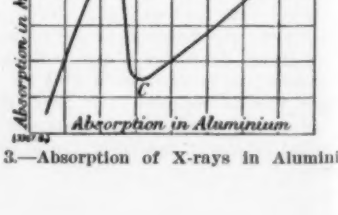


Fig. 3.—Absorption of X-rays in Aluminium.

atomic weights of which the one could not be differentiated from the other by means of chemical analysis. Ordinary spectrum analysis is equally at fault, since the character of the luminous spectrum is wholly due to the outer ring of corpuscles. Hence we might have elements apparently identical in their spectral and chemical properties, but differing by four in their atomic weight. The positive-ray method of analysis* would, on the other hand, distinguish between two such elements, since in this the weight of the individual atom is determined. I might add that those who have been most concerned in the investigation of the radioactive elements have arrived at the conclusion that some of the successive products of radioactivity are indistinguishable one from the other by chemical means. If the last stage of radium is lead, we ought, from the scheme shown in Fig. 1, to have three leads, all differing in their atomic weights, but incapable of separation by chemical tests. As stated, however, the positive-ray method of analysis would be able to distinguish between them.

On the other hand, in the β-ray changes chemical methods would succeed, while the positive-ray method would fail. In the β-ray transformation the atomic weight is only altered by $\frac{1}{1\,0\,0\,8}$th part of the atomic weight of hydrogen, so that the change leaves this atomic weight practically unaltered. Since, however, the change raises the group of the element by one, the chemical properties will be entirely altered. Thus radium B belongs to the fourth group, radium C to the fifth, and radium C^1 to the sixth group. All these three elements have thus the same atomic weight, but entirely different chemical properties. The sketch above given (Fig. 1) embodies some of the very interesting points suggested by the model atom I have brought forward, and they are, I think, worthy of consideration. It does not, indeed, appear possible to test the matter experimentally. I may, however, observe, that Röntgen rays, when they fall upon an element cause it to emit B particles, which, while nothing like so rapid as those liberated by the radioactive elements, have nevertheless so much energy that they are believed to come from the inner core. If this were so, the exposure of an element to Röntgen rays should change the chemical properties of the atoms affected, and it would be extremely interesting if evidence could be obtained of such an effect. I fear it is a forlorn hope, since such a minute fraction of the whole atoms present is affected; but it is one of the charms of physics that forlorn hopes are always coming off, and I think, therefore, it might be worth while to try if on exposure of an element to the Röntgen rays some evidence might not be obtained of a minute chemical change in the substances thus exposed.

It will be seen that the radioactive transformations lend considerable support to the model of the atom I have described. Further evidence can be obtained from the radiations emitted from the core of the atoms and from the surface.

Fortunately, within the last two or three years something has been learned as to the inside of the atoms. Nothing whatever was known as to this till Prof. Barkla discovered the "chracteristic" Röntgen radiations. He found, in fact, that each of the elements (at least each of the heavier elements) emitted a characteristic Röntgen radiation, which was merely a form of light. That this was so, had been known from theoretical considerations for a long time, but until recently, there had been no very direct experimental proof of the wave-like character of these rays. This condition of things arises because the wave-length of the Röntgen rays is only about one tenth the diameter of a molecule. As against the wave character of these rays it had been contended that they had not been reflected, nor had interference effects been obtained with them when they were allowed to fall on an ordinary grating.

There ought, however, to be some proportion between the wave-length of the light from which interference was expected and the spacing of the lines of the grating used. The benches upon which my audience is sitting are equally spaced, but is no argument against the wave theory of light to say that the light received from them shows no signs of interference. The spacing of the grating and the length of the wave must, in fact, be "within the same order." Hence, if the wave-length were comparable with the diameter of a molecule, the lines of the grating must not be more widely spaced than the distance between one molecule and another. Simillar considerations apply to the phenomenon of reflection. To give a regular reflection a surface must be flat—that is to say, the distance between the hills and the valleys must not be large as compared with the wave-length. Ribbed glass, for instance, does not reflect light regularly.

In the case of the Röntgen rays, therefore, a surface is required so smooth that its inequalities are not large in comparison with a molecule. Good as is the work of modern opticians, they are not able to produce a mirror true to a single molecule. It is, however, possible to find mirrors produced by the forces concerned in the formation of crystals. In these the molecules are arranged with extreme regularity, and it is possible to find in such crystals true reflecting planes. Considerations of this kind have led to experiments on the interference of Röntgen rays, and in Fig. 2 is reproduced the first photograph which shows the reflection and interference of Röntgen rays. This work, using crystal planes as reflectors, was carried out at the Cavendish Laboratory by Mr. W. L. Bragg. Mica was the substance used as the reflector, and in this material there is a great concentration of molecules along the cleavage planes. The large spot in the figure was produced by the incident radiation and the smaller by that reflected. Measurement shows that the reflection is regular, the angle of incidence being equal to the angle of reflection The smaller patches visible are interference fringes, and from these it is possible to calculate the wave-length of the Röntgen rays, which are undoubtedly a kind of light having, in the case of the rays used in producing Fig. 2, a wave-length of 10^{-9} centimeters.

Further evidence in support of the view that Röntgen rays are a kind of light is afforded by the experiments of Barkla, who has shown that each element emits from its inner core characteristic Röntgen radiation. In Fig. 3 is reproduced a curve of absorption of such rays. The abscissæ represent the absorption in aluminium of rays of varying hardness, and the ordinates the corresponding absorption in another metal. It will be seen that as the waves became harder the absorption in the metal under examination diminishes from A to C. At C the rays are of the same quality as the characteristic radiation of the metal under test, and, as will be seen, the absorption suddenly shoots up in a manner quite analogous with absorption of particular wave-lengths of light by bodies which naturally emit waves of this special length. One beauty of this characteristic Röntgen radiation lies in the fact that it is connected in an extremely simple way with the atomic weight. In no case is the Röntgen spectrum complicated, though many bodies are capable of emitting two sorts of Röntgen radiation.

The hardness of Röntgen rays can be specified by the speed of the cathode particle needed to produce them. Mr. Withington has shown that, taking the first kind of characteristic radiation, the cathode particle to excite it must have a velocity given by the following purely empirical rule:—Velocity in centimeters per second $= 10^8 \times W$, where W denoted the atomic weight. This first type of Röntgen radiation is known as the K type. The second line in the Röntgen spectrum is known as the L line, and there is a very simple connection between the atomic weights of two bodies, of which the K line of one is the same as the L line of the other According to Mr. Withington the following rule holds:

$$W_K = \tfrac{1}{2}(W_L - 48),$$

where W_K denoted the atomic weight of the first body, and W_L that of the second.

It will be seen, therefore, that if we know the atomic weight of an element, we can predict forthwith the hardness of its characteristic radiation.

I have already stated that when Röntgen rays fall on a body they make it emit negative corpuscles, which move with very great speeds. The harder the incident rays the higher is this speed. Light, too, when it falls on certain bodies causes the emission of negative particles, the speed of which depends on the wave-length of the light, being higher the smaller this wave-length.

[This fact was illustrated by the lecturer by means of a zinc plate connected up to a charged electroscope. This was illumined by the spark produced between two aluminium terminals by an induction coil. By placing a piece of glass between this light and the zinc the discharge of the electroscope was entirely prevented, since the glass, though transparent to the visible spectrum, absorbed the light of short wave-length. On removing the glass, the electroscope was almost instantly discharged, as the ultra-violet light, which then reached the zinc plate, gave the particles sufficient speed to enable them to escape.]

Though the inner core radiation is, as stated, very simple, that from the outer surface constitutes an extremely difficult study. Though there are but very few corpuscles in the hydrogen atom, the second spectrum alone comprises about 100 lines, most of which are given out by corpuscles in vibration, as can be proved by the Zeeman effect. The difficulty is to account for the large number of these lines in view of the small number of corpuscles.

A corpuscle can, however, vibrate in more than one way. It might, for example, oscillate like a pendulum about a position of equilibrium, but it would then have but one definite periodicity. In addition to the simple pendulum, however, we have also the conical pendulum. In this the bob goes round in a definite period, but there are any number of such periods possible. If a corpuscle acts like the bob of a conical pendulum, we should have more material to draw upon in endeavoring to account for the multiplicity of the lines. That the negative corpuscles can be sent round in a circle can be shown by means of an exhausted bulb containing a Wehnelt athode. This consists of a piece of platinium carrying a peck of barium oxide. If this platinium is made red-hot nd negatively electrified, the barium oxide gives off a copious stream of corpuscles, and by means of an external electromagnet it can be shown that this stream can be bent round into a circle, each therefore having a motion similar to the bob of a conical pendulum. It is not necessary that a magnetic field should be provided to secure this, as an electrostatic one will also serve and give the corpuscles definite orbits.

It is to some action of this kind that I am inclined to look in accounting for the presence of numerous lines in the spectrum of elements of small atomic weight.

(To be concluded.)

*See SCIENTIFIC AMERICAN SUPPLEMENT, January 20th, 1912 page 41; October 26th, 1912, page 268.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Simple Method of Preparing Tables of Cubes

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Having some work in hand where it became necessary for me to secure the cubes of a large number of consecutive numbers, and finding the usual method of multiplying very slow and unsatisfactory, I attempted to discover an easier method to secure my ends, and succeeded very well.

As I know that the readers of the SCIENTIFIC AMERICAN SUPPLEMENT are undoubtedly always looking for new and easier ways to obtain results, I am submitting my method to you, and you may publish it if you think it worth publishing.

To get the cube of consecutive numbers quickly and easily, without the need of multiplying as usual, the following method may be used, which will invariably give the correct answers.

a.	$9^3 = 729$	a.	$13^3 = 2197$	a.	$17^3 = 4913$
a.	$10^3 = 1000$	b.	469	b.	817
b.	271	c.	78	c.	102
c.	60				
		a.	$14^3 = 2744$	a.	$18^3 = 5832$
a.	$11^3 = 1331$	b.	547	b.	919
b.	331	c.	84	c.	108
c.	66				
		a.	$15^3 = 3375$	a.	$19^3 = 6859$
a.	$12^3 = 1728$	b.	631	b.	1027
b.	397	c.	90	c.	114
c.	72				
		a.	$16^3 = 4096$	a.	$20^3 = 8000$
a.	$13^3 = 2197$	b.	721		
		c.	96		
		a.	$17^3 = 4913$		

Take any two consecutive numbers, as 9 and 10, and find their cubes, which are, respectively, 729 and 1000. The difference between these figures, 271, plus 6 times the larger number chosen, which equals 60, added to the cube of the larger number, will give the cube of the next higher number.

In proceeding the easiest way is to add lines b and c of each term to get line b of the following one, and add 6 to line c of each term to get line c of the next term.

From this it becomes apparent that simple addition is all that is required to get the desired results.

Somerville, Mass. ARTHUR W. WEEDEN.

New Process for Refining Crude Oil

IN the Edeleanu process for refining crude mineral oil, the oil is treated with liquid sulphur dioxide, which extracts principally the high-carbon hydrocarbons. On agitating the oil with sulphur dioxide two layers are formed, the one rich in sulphur dioxide and hydrocarbons rich in carbon, the other poor in sulphur dioxide, and containing most of the saturated hydrocarbons. The separation is most effective at low temperatures, and the process is best effected at —5 deg. to —10 deg. Cent. As is well known in processes of this kind a higher efficiency is secured by repeated extractions with a small quantity of the solvent, than by a single extraction with a larger quantity.

Boron as a Constituent of the Animal Body

MESSRS. G. BERTRAND and Agulhon have investigated, by a special method of great sensitiveness, the occurrence of the element boron in the animal body. They have found it present in all animals, but more particularly in marine species. In some cases, as that of the trout and the leech, the amount present is about one one hundred millionth of the weight of the body.—*La Nature.*

NEW BOOKS, ETC.

OIL FINDING. An Introduction to the Geological Study of Petroleum. By E. H. Cunningham Craig, B.A., F.G.S. With an Introduction by Sir Boverton Redwood, Bart. New York: Longmans, Green & Co., 1912. 8vo.; 195 pp.; illustrated. Price, $2.40 net.

The author emphasizes the fact that in the discovery of areas rich in mineral oils, it is to the geologist one must look in the first instance, rather than to the engineer. The work is addressed primarily, then, to the geologist and the student; but the investor and the man of experience may alike benefit by his broad outlook, stimulating theories, and practical advice. Theoretical aspects are disposed of in the first part of the work, while the later chapters contain the clearest working knowledge extant. It is pointed out that, while it is not possible to be sure that petroleum lies beneath a given surface, it is quite often possible to assure one's self that it does not. Altogether the author's observations are of exceptional value.

MY EXPERIENCES AT NAN SHAN AND PORT ARTHUR WITH THE FIFTH EAST SIBERIAN RIFLES. By Lieut.-General N. A. Tretyakov. London: Hugh Rees, Ltd., 1911.

Lieut.-Gen. Tretyakov's narrative appeared originally in a Russian military journal. It may be regarded as a simple and intimate presentation of his experiences at Nan Shan, and within the beleaguered fortress of Port Arthur. To the soldier these annals afford example after example, deeply interesting and instructive, of military cause and effect. In theory a specialist's business, here we see laid bare the foundation on which stands scientific siege warfare. The infantry soldier's readiness to die makes possible the rôle of the gunner and the sapper—his blood cements their work. In this extraordinary book, we follow the fortunes of the General's own unit; we live with his men amid the blood-stained wreck of their trenches on 203 Meter Hill, losing all thought of the general conduct of the attack and defense of the fortress—in a word, we are transported from the dry bones of military history to the living realities of the battlefield. The author's regiment constituted the greater part of the garrison that fought the Japanese at Nan Shan, and the difficulties under which he labored foretold the failure of the Russians in Manchuria. His troubles were not unlike those under which American officers would be placed in time of war. For that reason his book is of peculiar interest to our Congressmen. The author's military training does not permit him to criticise his superiors, but it is very plain that Gen. Fock had singular lapses of common sense. The utter absence of any mention of Stoessel speaks louder than any condemnation. The author has no very high opinion of the Japanese as soldiers; for he tells us: "It is absurd to credit them with exceptional knowledge and skill in military science. Neither do I acknowledge that they are exceptionally brave, in which opinion my riflemen agree with me. The Japanese are very cautious, and they have no reason to boast of their daring. True, they attack without flinching; for this there are many reasons; first of all, their initial success; secondly, the numerical inferiority of our garrison; and thirdly, the fact that they may be peppered with shrapnel if they do not advance. I am absolutely convinced that in a future campaign, when we have a double line in Manchuria, when Vladivostok has been strongly fortified, when we have twice the number of guns, besides Maxims to every company, we shall utterly defeat them and drive them off the continent."

UNITY IN NATURE. An Analogy Between Music and Life. By C. E. Stromeyer. London: Sherratt & Hughes, 1911.

In his preface, Mr. Stromeyer tells us that being an engineer by choice and profession, it seemed but natural that the analogy with which his pages deal should, from the very first, have exerted a powerful fascination over him; for engineers lean almost entirely on analogy for their inspiration and progress. To him the fact has stood out with glaring distinctness that the existing philosophical system has been evolved during tens of centuries in which the great principle of the indestructibility of matter had not been established and that of the conservation of energy had not even been suggested; two principles on which every modern science is now securely resting. The author's desire has been to bring within the compass of human contemplation the all-embracing light of the Universe. "Such a complex cannot, of course, be represented on a single canvas, and a multitude of pictures would only obscure the view, nor can it be expressed by a single philosophical pronouncement. A semi-artistic and semi-philosophical process, one which led to the views contained in the book, has therefore been adopted of using music as an allegory of life." Consequently, the author has found it necessary to seek for the true nature of music, a subject which he has attempted to elucidate.

The first task which has to be undertaken is to convey the idea that music is an independent world, but so difficult has this task been found, that the assistance was called in of a sketch by an author calling himself "A Square," who tried to explain the nature of an independent world called "Flatland," to which subject one chapter in the present work is devoted. Then follows a chapter entitled "Music," in which an attempt is made to impart the feeling that music, as distinct from musical pieces, is without beginnings and without endings, and that in this respect at least it is similar to our world. The next chapter on "Laws," also aims at demonstrating the similarity and the independence of the two worlds by showing that they are both controlled by unalterable laws of nature.

These chapters may be looked upon as introductions, and now the process of contemplating each world from outside points of view is indulged in several times, the first question asked being: "What is the 'Essence of Life and of Music?'" The answer is that both are essentially dualisms: and then dealing lightly with the musical world, six rather substantial chapters follow on the dualism of the physical world, on "Matter and Energy." The next contemplations from the musical and physical points of view lead to the questions as to what is the inter-relation between a composer and his musical pieces and that of a Creator and His Creation. As the answer must necessarily suggest the possibility of the existence of a spiritual world which is as superior as regards dimensions as ours is to the world of music, the above subjects are preceded by a chapter on the "Fourth Dimension," in which it is suggested that the abode of a Creator is not likely to be in a world which has merely one more dimension than ours. The suggestion is there thrown out that a study of electricity does at least suggest the existence of other worlds.

THE FLIGHT OF BIRDS. By F. W. Headley. London: Witherby & Co. New York: Charles Scribner's Sons, 1912. 8vo.; 160 pp.; 16 plates; 27 figs.

This is the work of an ornithologist who in eleven chapters discusses many phases of the flight of birds, and of their flying organs and environment. It is written in an easy, popular style, free from needless technical terms, yet manifests considerable acquaintance with the literature of ornithology, of aviation, and of the allied branches. It is illustrated by many photographs, taken by the author himself to illustrate the typical attitudes of flight, and here published for the first time. Besides these apt and original illustrations, gathered in the author's frequent journeys about England, Europe and northern Africa, the book abounds with appropriate and instructive observations which mark the writer as an enthusiastic student of birds in their native habitats and most varied activities. Indeed, the original illustrations by fact and figure, the explanations and theories, are so copious as in some parts to indicate that the author was unaware that he was traversing an old and well-beaten range of science where capable specialists had preceded him, describing and explaining the same phenomena, and in treatises that might very justly and profitably be brought to the reader's notice.

The early chapters touch lightly on some of the laws and phenomena of aerodynamics. The resistance of the air is discussed, particularly its lift, drift and center of pressure on shapes suitable for the wings of aeroplanes. The power required for propulsion and the conditions promotive of steadiness and stability are next treated, then the various devices and maneuvers by which the bird controls its poise in the air under various conditions of its movement and that of the air it navigates.

Following Marey's "Vol des Oiseaux," a good account of the bird's movements, particularly its wing movements, during forward flight is given. In this the author is clear and orthodox, so far as he goes. But he does not describe in any detail the wing movements during stationary flight, and apparently does not believe such flight possible for the birds, except in a rising wind. In this doctrine he is not so orthodox; for many birds, particularly the smaller ones, can maintain stationary flight without an ascending wind, and furthermore the poise of body and movement of wing in that maneuver have been adequately described by others. His description of the bird's starting, steering, stopping and alighting are full of interesting detail, and well illustrated. In this he makes no reference to the famous little book, "Du Vol des Oiseau" of Count d'Esterus, treating the same topics. Nor does he anywhere refer to Chanute's important writings on bird flight, and Mouillard's fascinating book, "Empire de l'Air," which did so much to promote the cause of aviation.

The author writes with a firm and easy hand on the anatomy and physiology of birds, their evolution, modes of life, and on all topics in pure ornithology. These parts of the work are to be especially commended to the reader, particularly the chapters on wing structure and the machinery of flight. His chapter on the voyages and migrations of birds, their speed and endurance, is full of interesting and, in some cases, modern data.

The chapter on Flight and Wind might well be revised by some one who is well grounded in mechanics, and who at the same time is familiar with meteorology and the literature of passive flight. Descriptions and explanations of the wonderful evolutions of birds in sailing and soaring without motive power have been given by many able physicists and mechanicians, beginning with Lord Rayleigh, and some inkling of their conclusions would be quite as welcome and advantageous to the reader as the author's apparently original and sometimes mistaken views. He correctly describes soaring in a rectilinear course on an ascending current (except that Fig. 27 is inverted), but later defines soaring as a spiral ascent of a bird in the air, effected without taking any strokes with his wings. Obviously this defines only spiral soaring. A broader and more generally accepted definition would be "gliding by force of the wind without loss of altitude," as given in the SCIENTIFIC AMERICAN for November 18th, 1911. Some minor slips in aerodynamics, such as the unwarranted criticism of Newton, borrowed from writers who misapprehended his meaning, might also be corrected. And it might have been well not to deny too positively the possibility of soaring in a variable horizontal wind, since Rayleigh and others have explained correctly how the feat can be achieved in certain conditions.

Aside from these venial sins against the mechanical sciences this charming book on bird flight by an enthusiastic observer and pleasant writer, should appeal to a large class who, "whether scientific ornithologists or not, take a delight in birds, and their doings."

THE NAM FAMILY. A Study in Cacogenics. By Arthur H. Estabrook and Charles B. Davenport. With four charts and four text figures. Cold Spring Harbor, New York: The Eugenics Record Office, 1912.

THE HILL FOLK. Report on a Rural Community of Hereditary Defectives. By Florence M. Danielson, M.A., and Charles B. Davenport. With three folding charts and four text figures. Cold Spring Harbor, New York: The Eugenics Record Office, 1912.

These two monographs are excellent examples of the work that must be done before it is possible to advocate legislation which will carry out the eugenic idea of preventing the propagation of the socially unfit and of raising the general average of the human race. The writings of Sir Francis Galton, Karl Pearson, Dr. Davenport, Dr. Schallmeyer, and others have driven home the necessity of studying the manner in which human diseases, both physical and mental, are transmitted from generation to generation. What is now wanted is specific information on a large number of cases in which physical and mental defects have been transmitted. The human being is such a highly complicated organism, that it is no easy matter to apply to him the Mendelian laws of heredity, to which he is unquestionably as amenable as any plant or animal. There is also to be overcome pride and prejudice. What man, for example, is willing to admit that an ancestor of his was a negro? The methods which must be adopted are admirably exemplified in these two monographs. Here we have a record of two families in which criminality, drunkenness, loose living and vicious habits have been clearly transmitted from generation to generation. Fortunately for society, the families discussed are more or less isolated in rural communities, so that their influence, while not negligible, is still comparatively slight. Change of environment could hardly better the conditions of these families. Bad germ plasm remains bad germ plasm, whether it flourishes in a hovel or a palace. That fact stands out clearly in both these monographs.

One of these monographs was published with the financial assistance of Mr. John D. Rockefeller, and the other of Mr. Rockefeller and Mrs. E. H. Harriman—proof that men and women of wealth realize how important are investigations of this kind, and how much more valuable they are than the donation of large sums to charity.

ENGINEER'S HANDBOOK ON PATENTS. By William Macomber, Author of "The Fixed Law of Patents." 12mo. Flexible leather. Price, $2.50 net.

Mr. Macomber's writings on patent law in various periodicals have deservedly attracted attention. His work on "The Fixed Law of Patents" may be regarded as a supplement to the classical Robinson. In the little book that lies before us, he has presented in a most concise form all that the technical man should know of the patent monopoly, its nature and its operation. Particularly now, when the Oldfield bill is attracting so much attention, Mr. Macomber's book should be read by all engineers. Few technical men realize how important the patent system has been in the development of this country, and how much we owe to inventors, who have received encouragement from one of the most far-seeing pieces of legislation that the founders of this country constitutionally authorized. In his introductory chapter Mr. Macomber shows how the old type of inventor is gradually giving place to the engineering type, and why for that reason the engineer should interest himself in patent law. Next he passes on to the nature of a patent, tracing the rights of the patentee from the Constitution through the patent laws and the various decisions that have interpreted the laws. In the third chapter he discusses the nature of inventions, and then passes on to the patentability of inventions. Patent procedure is taken up in a chapter entitled "The Obtaining of Patents." Excellent is the chapter on claim construction, for it drives home the exceeding importance of properly drawn claims.

The final chapters are devoted to infringements, patent litigation, and property rights. Taken all in all, Mr. Macomber has contributed a very useful text book to the rather scant literature on patents that an engineer would care to read.

BUCH BERUEHMTER INGENIEURE. [illegible] Dr. Richard Hennig. Leipzig: [illegible] von Otto Spamer, 1911. Price, $1.7[illegible]

This book is intended for popular reading. The list of engineers selected includes Wilhelm Siemens, James Buchanan Eads, John Ericsson, Ferdinand de Lesseps, Alfred Nobel, Sir Henry Bessemer, John Fowler, Nikolaus Riggenbach, Otto Intze, Max von Eyth, and is, therefore, fairly cosmopolitan in character. It is [illegible] enough to cite names which it would seem ought to have been included. For instance, Brunel should have had a whole chapter devoted to him. But after all, such criticism is [illegible] captious. The tendency in any book of this kind is that of failing to appreciate the work which has been done in other countries. The criticism can hardly be leveled at the author of this book, since he has included Americans, Englishmen, Frenchmen, and Swedes, as well as Germans. The author has adopted a style admirably suited for popular reading, and has presented his facts most interestingly. Books such as this ought to be read by the undergraduates of every technical institution.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

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